ESD-TR-65-11

PREDICTION OF WINTER AND SUMMER CYCLONES

Frederick P. Ostby
Keith W. Veigas

July 1965

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433L SYSTEM PROGRAM OFFICE
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
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L. G. Hanscom Field, Bedford, Mass.

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FOREWORD

System 433L; project 1.0; task 1.7. This TR has been prepared for United Aircraft Corporation, East Hartford, Conn., under Subcontract no. 15107 to Contract no. AF19(628)-3437, by The Travelers Research Center, Inc., 250 Constitution Plaza, Hartford, Conn. The Research Center's publication number is 7463-173. Robert L. Houghten, Lt. Colonel, USAF, is Acting System Program Director. This report covers the period October 64—June 65, and was submitted for approval on 2 July, 1965.

Special thanks are tendered to Mr. Paul MacDonald, who supervised the data processing phase of this study, and to Miss Rachel Williams and Mrs. Robert Corso for their data tabulation efforts. Also, thanks are given to the U.S. Weather Bureau for the file of manuscript maps made available to us.

ABSTRACT

This report presents results and equations for the 12-, 24-, and 36-hr prediction of cyclone displacement and change in central pressure for the Northern Hemisphere. For application of these equations to summer cyclones, the Northern Hemisphere was divided into six areas; for application to winter cyclones, only three of these areas were treated because the other three were covered previously.

The technique employed features a moving-coordinate grid system for predictor tabulation, and a screening regression analysis for the derivation of the prediction equations.

These equations were tested on an independent data sample and yielded results superior to climatology for all areas tested. The incorporation of 500-mb perfect prognoses as predictors appeared to have only limited success.

REVIEW AND APPROVAL

Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Robert L. Houghten
Robert L. Houghten
Lt. Colonel, USAF
Acting System Program Director

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SECTION I

INTRODUCTION

Previous studies in cyclone prediction [6, 7], in which the method for predicting the movement and intensification of a cyclone was to use statistically derived prediction equations based on a moving-coordinate system (one in which predictor information is measured at fixed points relative to the moving cyclone rather than relative to the earth), showed considerable skill and warrant application to untreated geographical areas and seasons.

The prediction equations can be used operationally either manually with the aid of a desk calculator or, as is done at the USAF Global Weather Center (GWC), automatically with the aid of an electronic computer.

This report treats summer-cyclone equations for the Northern Hemisphere (divided into six areas), and winter-cyclone equations for the Atlantic and Pacific Oceans and Eurasia.

SECTION II

DATA PROCESSING

1. Areas Studied

The areas selected for study are shown in Fig. 1. Summer-cyclone equations were derived for all six areas, while only three of the six areas were considered for winter cyclones (the other three areas were considered previously [6, 7]).

2. Selection of Cases

Cyclones were processed separately according to the area in which they were located. Table I shows the number of cyclones selected for each of the areas of Fig. 1. The cyclones were selected by examining all the 0000 and 1200 GMT surface charts for the winters (November-March) of 1955-56 through 1959-60, and the summers (May-September) of 1955 through 1959. A cyclone was accepted if it retained its identity for at least 36 hours.

The samples of cyclones selected for the first four winters and summers were designated as the dependent samples and were used to derive prediction equations. The samples of the fifth winter and summer seasons were designated as the independent samples and were used to test the equations.

3. Predictands

The predictands used in this study were in the same form as in previous studies [6, 7]; that is, the two components of displacement (latitudinal and longitudinal), and change in central pressure, for 12, 24, and 36 hr (see Table II).

4. Predictors Considered

The basic source of predictor data was System 433L hemispheric-data tapes [8]. Special preprocessing programs automatically extracted grid-point arrays of the various pressure, height, and thickness data for each cyclone in the developmental sample. In addition, several so-called derived predictors were computed by conventional finite-difference methods. This yielded seven grid arrays of 63 points each, plus 17 single-point predictors, or about 460 potential predictors.

Because the screening regression program (see Section 6) will treat no more than 180 possible predictors at one time, the number of predictors was subjectively decreased for each grid-point array. Table III lists the possible predictors that remained after this reduction. There are two categories: SIMPLE predictors from Category A and DERIVED

TABLE I

SELECTED SUMMER AND WINTER CYCLONES, 1955—1960

Area*	No. of summer cyclones			No. of winter cyclones		
	1955—1958	1959	1955—1959	1955/56—1958/59	1959/1960	1955/56—1959/60
North America	710	171	881	—	—	—
Atlantic	743	219	962	1009	255	1264
Europe	495	77	572	—	—	—
Eurasia	436	144	580	537	140	677
Asia	876	241	1117	—	—	—
Pacific	684	162	846	1056	245	1301

*See Fig. 1.

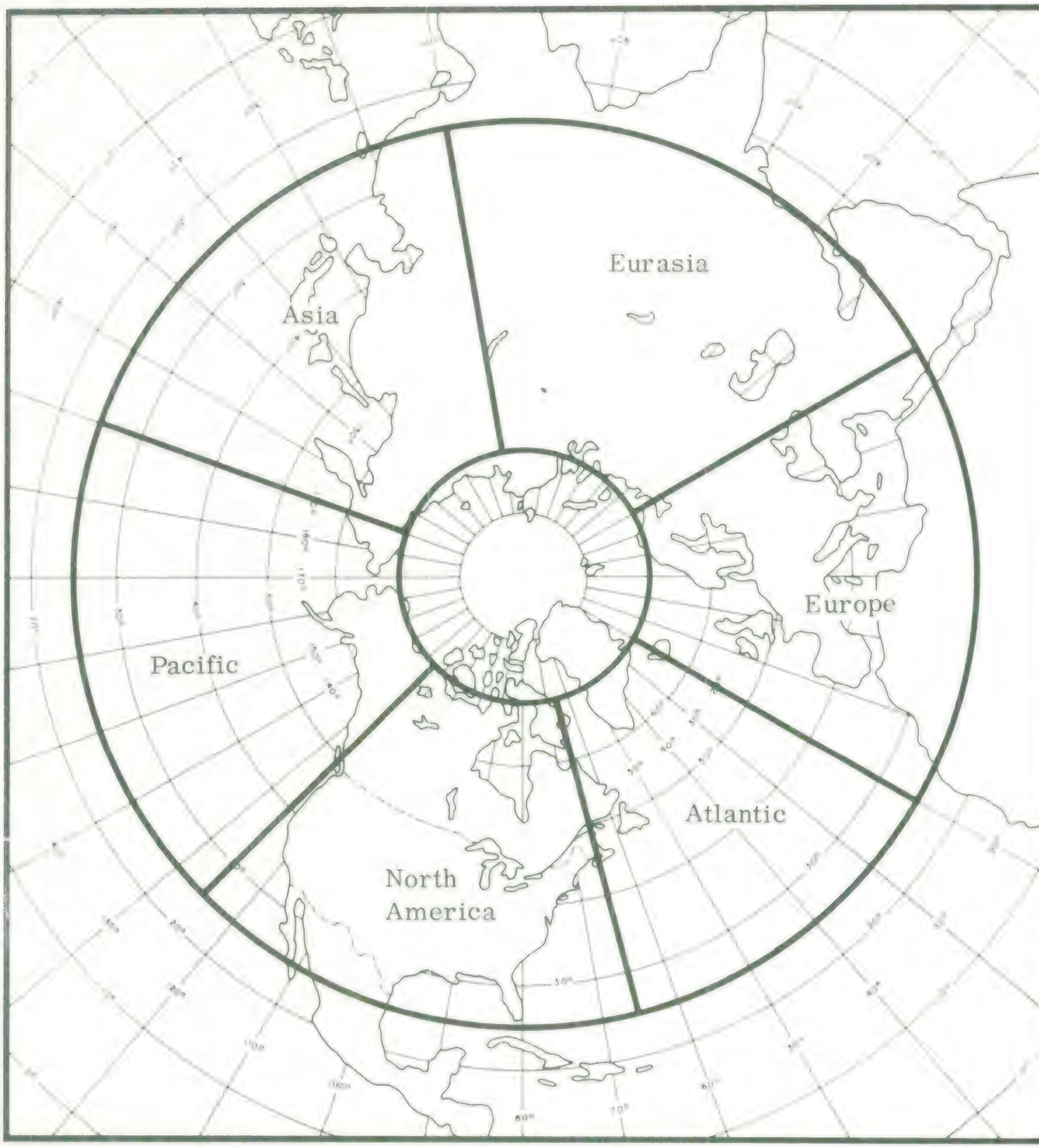

Fig. 1. Definition of Cyclone Areas

TABLE II
PREDICTANDS

Class	Symbol	Unit of measurement
Northward displacement	$\hat{N}$	deg. lat.
Eastward displacement	$\hat{E}$	deg. lat.
Change in central pressure	$\hat{D}$	mb

predictors from Category B.

The cyclone intensity (I) refers to the difference in pressure between the cyclone and the average of four surrounding grid points (derived from one grid interval for I_1 and from two grid intervals for I_2) divided by a function of latitude, so that

$$I = [\frac{1}{4} \Sigma (P) - P_0] \div (1 + \sin \Theta)^2 \qquad \text{(II-1)}$$

The two components, U' and V', of the thermal wind, $\vec{V}_T$ are computed for the location of the cyclone from the 1000- to 500-mb thickness chart. Because the 1000- to 500-mb thermal wind ($\vec{V}_T$) represents the difference between the 500-mb geostrophic wind ($\vec{V}_5$) and the 1000-mb geostrophic wind ($\vec{V}_0$), it can be seen that at the cyclone center, $|\vec{V}_5| >> |\vec{V}_0|$, and therefore, a reasonable approximation is $|\vec{V}_T| \approx |\vec{V}_5|$. Thus, U' and V' can be thought of as so-called "steering components". The concept of steering, well known to synoptic meteorologists, refers to the tendency for a cyclone to move in the direction of the mid-tropospheric flow above it and at a speed roughly proportional to the strength of the flow.

Vorticity, advection, and time changes of these quantities are computed at the cyclone location in the usual manner.

5. The Moving-coordinate Grid

The grid for extracting predictor information accompanies the cyclone as it moves, so variables are measured at constant positions relative to its center. The grid is shown in Fig. 2. The grid point defined by the (K, L)-location (5, 3) is placed at the center of the cyclone for summer and (5, 4) for winter, and the grid is oriented so that the line K=5 coincides with the meridian passing through the center of the cyclone. Other grid locations are defined by their departure, in grid intervals, from this point. For technique-development purposes, grid placement and data tabulation are done by computer programs, and "analyzed maps" are on magnetic tape. On a polar stereographic projection

TABLE III
POSSIBLE PREDICTORS

	Predictor	Symbol	Unit
Category A	Sea-level pressure	P	mb
	12-hr pressure change	ΔP	mb
	500-mb height	Z	decafeet
	12-hr height change	ΔZ	decafeet
	1000- to 500-mb thickness	H	decafeet
	12-hr thickness change	ΔH	decafeet
	Latitude of cyclones	θ	°lat.
	Longitude of cyclones	λ	°long.
	Cyclone intensity (one grid interval)	I_1	mb
	Cyclone intensity (two grid intervals)	I_2	mb
Category B	24-hr 500-mb height change (forecast)	$\Delta\hat{Z}$	decafeet
	Zonal component of 1000- to 500-mb thermal wind	U'	knots
	Meridional component of 1000- to 500-mb thermal wind	V'	knots
	Magnitude of thermal wind	V	knots
	Square of magnitude of thermal wind	V^2	$(\text{knots})^2$
	500-mb vorticity	η_5	sec^{-1}
	12-hr vorticity change	$\Delta\eta_5$	sec^{-1}
	Thermal vorticity (1000—500 mb)	ζ_T	sec^{-1}
	12-hr thermal vorticity change	$\Delta\zeta_T$	sec^{-1}
	Surface vorticity	η_0	sec^{-1}
	12-hr surface vorticity change	$\Delta\eta_0$	sec^{-1}
	Thickness advection	A_T	decafeet sec^{-1}
	12-hr thickness advection change	ΔA_T	decafeet sec^{-1}

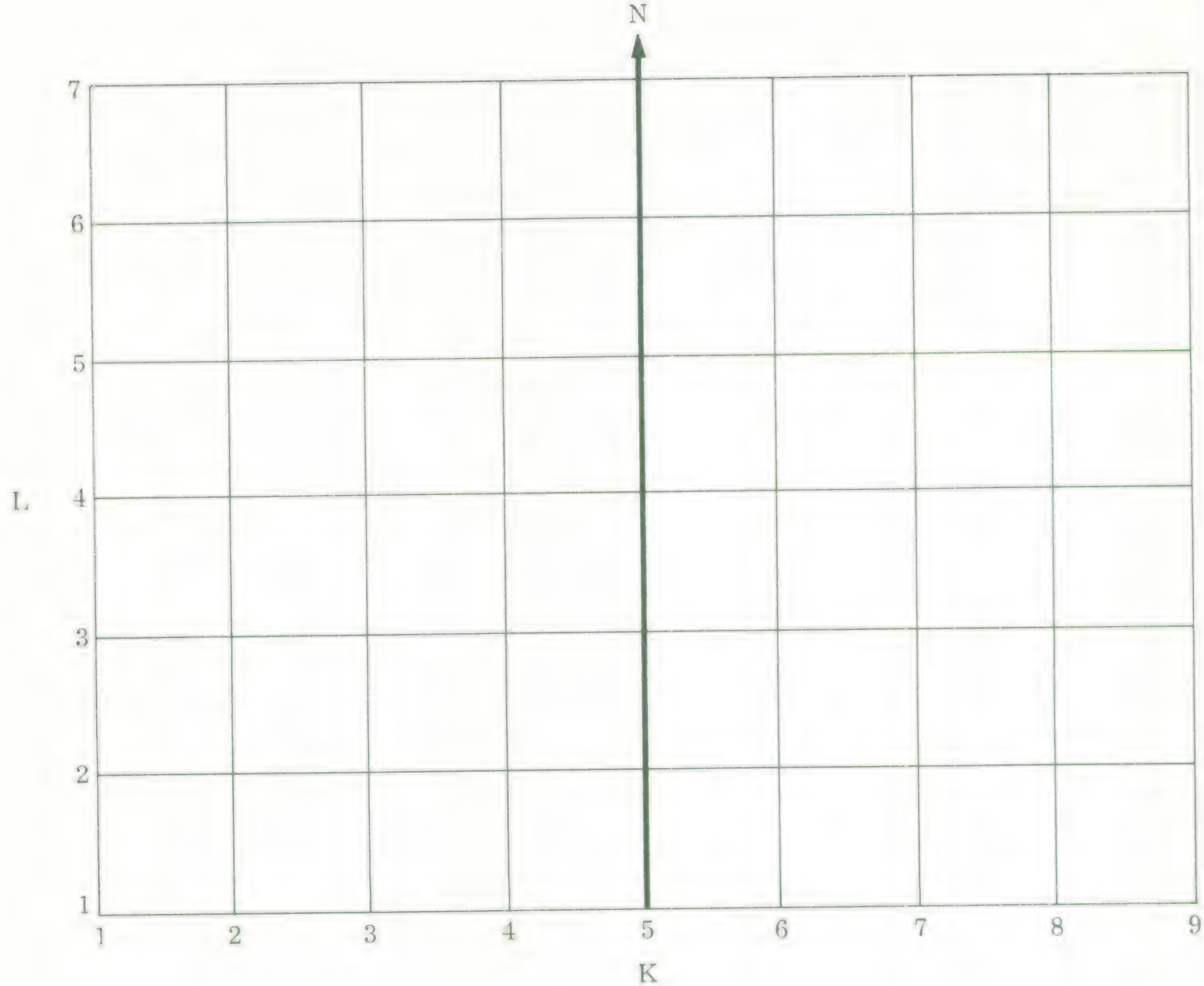

Fig. 2. Moving coordinate grid overlay. The center of the cyclone is positioned at K=5, L=3 for summer cyclones and K=5, L=4 for winter cyclones with K=5 oriented north-south. One grid interval equals two JNWP grid intervals (762 km at 60° N).

with standard parallel at 60°N, the grid array forms a set of evenly spaced points. The interval used here is twice that of the Joint Numerical Weather Prediction (JNWP) grid. At 60°N, where the scale is true, our interval equals 762 km.

6. Screening Regression Technique

The screening procedure suggested by Bryan [2] and developed for the IBM 704 electronic computer by Miller [4] was used to screen the possible predictors identified in subsequent sections (this program has also been written for the IBM 7094).

One who designs a statistical-prediction experiment invariably likes to consider all predictors deemed important on the basis of previous theoretical, synoptic, and empirical work, but as Lorenz [3] points out, a prediction equation should contain few predictors in comparison with the size of the developmental sample; if there are too many, a relationship that fits the sample used to establish it is likely to fail when applied to a new sample. The object of the screening procedure is to select from a set of possible predictors the subset that most significantly and independently contributes to reducing the variance of the predictand.

From an array of possible predictors, the screening procedure first selects the one that has the highest linear correlation with the predictand in question. This predictor is then held constant and partial-correlation coefficients between the predictand and each of the remaining predictors are examined; the predictor now associated with the highest coefficient is the second one selected. Additional predictors are chosen similarly. Selection is halted whenever a predictor fails to pass a significance test. After the significant predictors have been selected, the regression coefficients are obtained by the method of least squares.

The criterion of significance, as applied to the screening procedure, is not clear-cut because the usual F-test methods (e.g., [9]) are not applicable [5].

If a predictor is chosen at random from a group of predictors, an F-test is usually taken at the 95% level; this allows a 1-in-20 chance of considering the predictor significant when, in fact, it is not. Because the screening procedure does not select predictors randomly, a more severe test is needed to specify a 1-in-20 chance. For his screening procedure, Miller [5] suggested that the critical F-value be a function of the number of possible predictors. The F-test was used in this form in these experiments.

SECTION III

SYNOPTIC CLIMATOLOGY

7. Summer Cyclones

Table IV contains the means and standard deviations of northward and eastward displacements, and the changes in central pressure for 12, 24, and 36 hr for the summer cyclones in the dependent data sample. Mean tracks were also constructed from this information and are shown in Fig. 3. A comparison of these six tracks shows a general southwest to northeast movement for the 36-hr period. Changes in central pressure are generally small, with the major amount of deepening occurring during the first 24 hr and a slight filling tendency in the last 12 hr. By comparing the standard deviations in Table IV, it is seen that there is generally more variability in eastward displacement than in northward displacement.

8. Winter Cyclones

Means and standard deviations for winter cyclones were also computed and are shown in Table V. The mean tracks are shown in Fig. 4. The prevailing direction of movement is toward the northeast for all three areas. Note that while the Atlantic area cyclones exhibited a fair amount of deepening, the tendency was for increasing central pressure for the Eurasian and Pacific areas. The standard deviations in Table V show the Eurasian cyclones to be somewhat anomalous in that their variability of displacement is greater latitudinally than longitudinally. The comparison of standard deviations between winter and summer cyclones shows, as one would expect, more variability in winter than in summer.

TABLE IV
CHARACTERISTICS OF SUMMER CYCLONES,
1955—1958 (dependent sample)

Area	Forecast interval, hr	Observed northward displacement, deg. lat.		Observed eastward displacement, deg. lat.		Observed change in central pressure, mb	
		Mean	Std. dev.	Mean	Std. dev.	Mean*	Std. dev.
North America	12	0.69	2.04	3.32	1.98	-1.16	3.66
	24	1.56	3.63	6.51	3.63	-1.96	5.62
	36	2.60	4.95	9.47	5.21	-2.26	7.26
Atlantic	12	1.50	2.05	2.92	2.08	-1.76	4.50
	24	3.06	3.64	5.48	3.78	-2.67	7.13
	36	4.57	4.87	7.65	5.35	-2.66	9.38
Europe	12	1.05	1.99	2.43	1.92	-0.91	3.59
	24	2.12	3.20	4.59	3.74	-1.07	5.72
	36	3.09	4.27	6.90	4.48	-0.58	7.45
Eurasia	12	0.85	1.76	2.77	1.94	-0.73	3.49
	24	1.68	2.92	5.48	3.37	-1.25	4.86
	36	2.50	3.96	8.09	4.75	-1.27	6.38
Asia	12	1.10	2.06	3.30	2.27	-1.10	4.27
	24	2.20	3.35	6.52	3.80	-1.69	6.48
	36	3.16	4.43	9.55	5.22	-1.61	8.40
Pacific	12	1.50	1.92	2.75	2.40	-0.92	5.04
	24	2.92	3.33	4.81	4.17	-0.49	8.11
	36	4.14	4.42	6.35	5.60	1.02	10.49

*Negative values represent deepening.

TABLE V
CHARACTERISTICS OF WINTER CYCLONES
1955/56—1958/59 (dependent sample)

Area	Forecast interval, hr	Observed northward displacement, deg. lat.		Observed eastward displacement, deg. lat.		Observed change in central pressure, mb	
		Mean	Std. dev.	Mean	Std. dev.	Mean*	Std. dev.
Atlantic	12	2.44	2.76	3.09	2.96	-3.97	8.87
	24	4.69	4.86	5.43	5.27	-6.07	13.27
	36	6.51	6.56	7.26	7.31	-5.57	16.74
Eurasia	12	0.86	2.51	3.09	2.19	0.32	4.42
	24	1.79	4.40	6.04	3.94	1.26	6.67
	36	2.75	6.04	8.77	5.55	3.00	8.42
Pacific	12	1.80	2.73	2.99	2.87	-1.48	6.86
	24	3.50	4.59	5.38	5.07	-0.97	10.91
	36	4.89	6.12	7.23	6.92	1.61	13.86

*Negative values represent deepening.

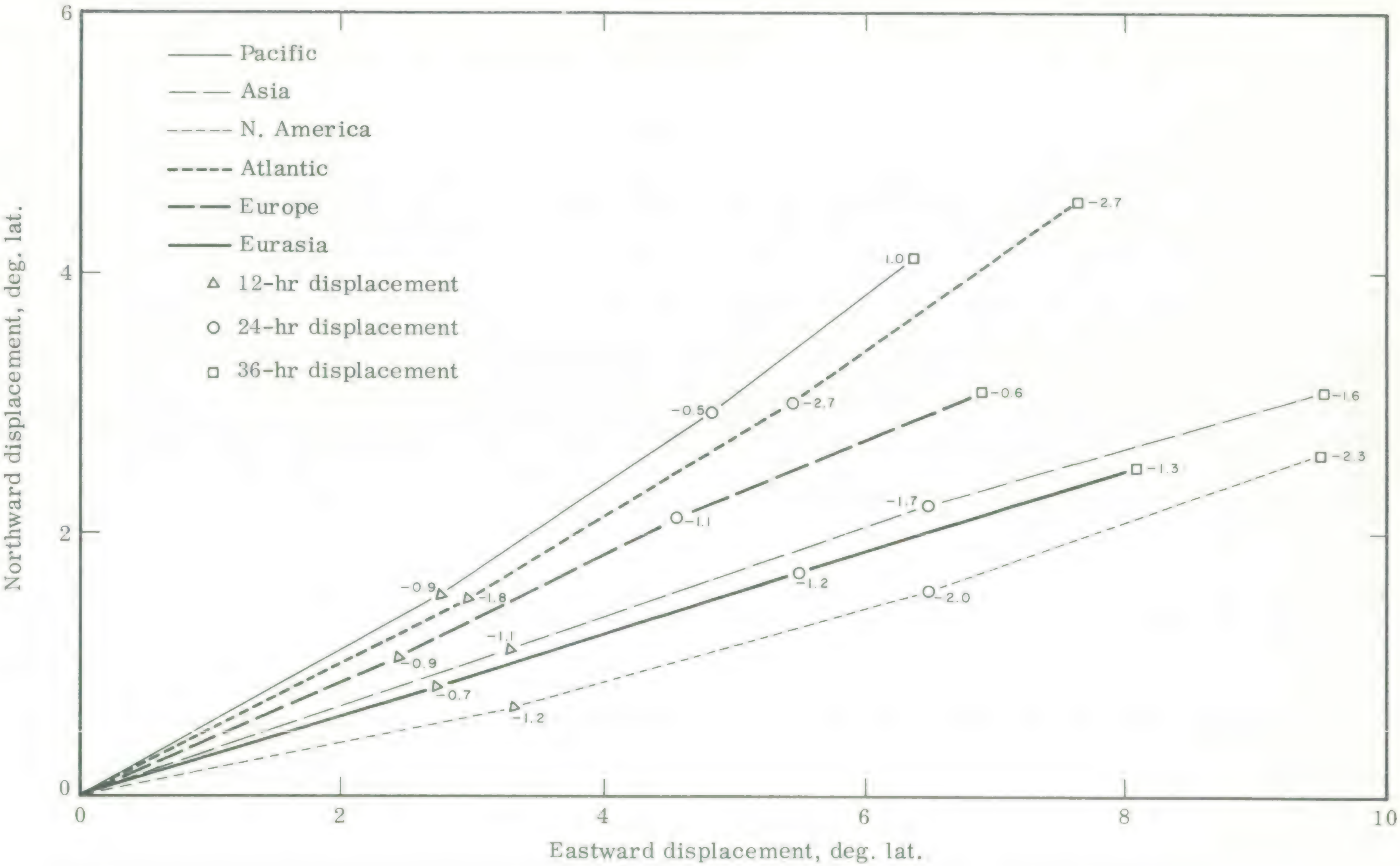

Fig. 3. Mean tracks of summer cyclones by area, 1955-1958 (dependent sample). Value adjacent to symbol refers to mean change in central pressure (mb).

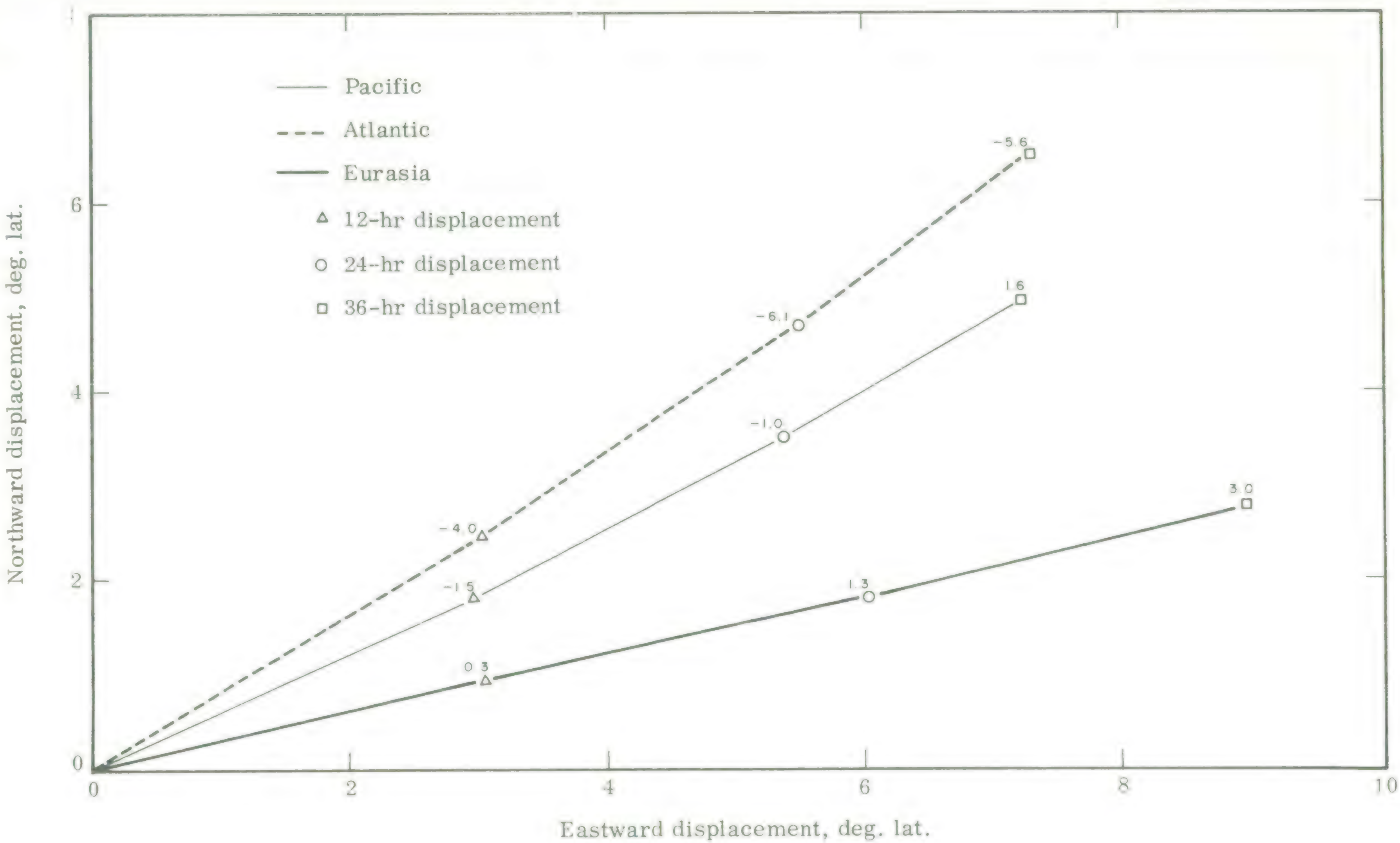

Fig. 4. Mean tracks of winter cyclones by area, 1955/56—1958/59 (dependent sample). Value adjacent to symbol refers to mean change in central pressure (mb).

SECTION IV

PREDICTION EXPERIMENTS

As was mentioned previously, all the possible predictors listed in Table III could not be used in a single computer run for screening-regression prediction experiments because of program limitations. Each set of predictor variables was reduced to a smaller subset which, based on earlier studies [6, 7], appeared to be near-optimum. We performed two kinds of experiments for all six summer and three winter areas. In the first (Exp. 1) our "base-technique" experiment employed, primarily, point values of the various predictors. In the second (Exp. 2), both derived and prognostic information were incorporated.

The predictors used in Exp. 1 consisted of only those in the upper half of Table III. Experiment 2 used the entire list of Table III. The results of these techniques are given in Section VI.

SECTION VI

RESULTS

For both summer and winter cyclones, the experiments were designed to yield seperate equations for the two components of displacement (northward, N, and eastward, E) and one equation for change in central pressure (D). Equations were derived for forecast intervals of 12, 24, and 36 hr. These equations can be found in the Appendix. The cyclone center was referenced to the (K,L) grid-point location (5,3) for summer cyclones and (5,4) for winter cyclones.

The results of the screening regression analysis are summarized in tables for each summer and winter area. Each table represents one area and lists, for both experiments, the predictors in the order of their selection by the screening procedure, and the percentage of the total variance of the predictand explained by each (% red.). The predictor symbol is defined in Table II and the accompanying numbers in parentheses refer to the (K,L)-grid locations shown in Fig. 2.

9. North American Summer Cyclones

Table VI (b), (Exp.2), shows that the first predictor selected for all six displacement predictands is a "steering" term. For northward displacement (N) it is the strength of the southerly flow (V´), while for eastward displacement (E), the westerly flow (U´) is most important. For the change in central pressure (D), the first predictor selected is the 24-hr forecast of 500-mb height change one grid-interval to the east of the cyclone. The sign of the regression coefficient associated with this predictor (see the Appendix) is positive; this relates cyclone deepening to prognostic height falls.

When derived predictors and prognostic terms are not used (Exp.1), the character of the selected predictors changes [See Table VI (a)]. It is interesting to note that, in general, there are many more 500-mb predictors than surface predictors. Some of these 500-mb predictors appear to simulate steering terms which were not explicitly available in this experiment. For example, the eastward displacement (E) has Z(6,5) and Z(5,2) as its first two predictors. Reference to the Appendix shows that these two terms have regression coefficients of opposite sign, so that the difference between the two is of importance. Furthermore, it can be seen from Fig. 2 that the locations of these predictors are such that they are measuring the westerly component of the 500-mb geostrophic wind. Likewise, the first two terms for the northward displacement (N) are

TABLE VI
PREDICTORS SELECTED BY SCREENING REGRESSION FOR NORTH AMERICAN SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\bar{N}$ Predictor	$\bar{N}$ % red.	$\bar{E}$ Predictor	$\bar{E}$ % red.	$\bar{D}$ Predictor	$\bar{D}$ % red.
	1	Z(7, 2)	12.4	Z(6, 5)	17.6	I_1	12.4
	2	Z(4, 3)	15.8	Z(5, 2)	7.9	ΔZ(4, 3)	7.9
	3	ΔP(5, 4)	4.2	Z(5, 4)	11.9	ΔZ(5, 2)	3.9
	4	Z(8, 5)	4.9	ΔP(6, 3)	2.4	H(4, 5)	1.9
12	5	P(1, 1)	2.1	ΔP(4, 3)	2.4	—	—
	6	Z(6, 3)	4.1	I_2	1.6	—	—
	7	Z(5, 4)	4.3	Z(4, 3)	0.9	—	—
	8	Z(5, 2)	2.0	P(6, 3)	1.0	—	—
	9	—	—	P(5, 2)	2.0	—	—
Total			49.8		47.7		26.1
	1	Z(7, 2)	10.9	Z(6, 5)	21.7	I_1	14.0
	2	Z(4, 3)	16.5	Z(5, 2)	12.2	ΔZ(4, 3)	6.0
	3	Z(8, 5)	7.0	Z(5, 4)	6.5	ΔZ(3, 2)	3.4
	4	ΔZ(5, 4)	4.6	ΔZ(4, 3)	2.5	P(4, 3)	3.2
24	5	Z(4, 5)	2.6	ΔZ(6, 3)	2.3	ΔP(6, 3)	2.8
	6	P(1, 1)	2.0	—	—	—	—
	7	Z(6, 3)	3.2	—	—	—	—
	8	Z(5, 4)	2.6	—	—	—	—
	9	Z(5, 2)	2.6	—	—	—	—
	10	ΔP(5, 4)	1.3	—	—	—	—
Total			53.3		45.2		29.4
	1	Z(8, 3)	10.6	Z(6, 5)	21.8	I_1	15.9
	2	Z(4, 3)	15.2	Z(5, 2)	13.0	P(4, 3)	3.6
	3	ΔZ(5, 4)	5.3	Z(5, 4)	2.2	ΔZ(4, 3)	4.3
	4	Z(8, 5)	5.6	ΔZ(4, 3)	2.8	ΔP(6, 3)	2.9
	5	Z(4, 5)	2.5	ΔZ(6, 3)	1.7	H(4, 5)	1.9
	6	Z(7, 2)	2.3	—	—	—	—
	7	P(2, 3)	1.7	—	—	—	—
36	8	H(8, 3)	1.0	—	—	—	—
	9	H(6, 3)	1.1	—	—	—	—
	10	Z(5, 4)	3.6	—	—	—	—
	11	ΔH(5, 4)	1.2	—	—	—	—
	12	I_2	1.0	—	—	—	—
	13	Z(1, 4)	0.9	—	—	—	—
	14	Z(9, 1)	0.9	—	—	—	—
Total			52.9		41.5		28.6

TABLE VI

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$ Predictor	$\hat{N}$ % red.	$\hat{E}$ Predictor	$\hat{E}$ % red.	$\bar{D}$ Predictor	$\bar{D}$ % red.
12	1	V'	24.6	U'	26.7	$\Delta\hat{Z}(6, 3)$	17.5
	2	λ	8.9	$Z(6, 5)$	4.4	I_1	19.3
	3	$\Delta P(5, 4)$	5.5	$\Delta\hat{Z}(6, 5)$	3.7	$\Delta Z(4, 3)$	4.4
	4	$P(3, 2)$	2.5	Λ_T	2.7	$\Delta\eta_0$	2.3
	5	$P(8, 3)$	1.7	$\Delta P(6, 3)$	1.8	—	—
	6	$P(5, 4)$	1.3	$Z(5, 2)$	1.8	—	—
	7	$P(5, 2)$	1.8	$Z(5, 4)$	2.8	—	—
	8	$\Delta\hat{Z}(5, 2)$	1.0	$\Delta\hat{Z}(5, 4)$	2.2	—	—
	9	$\Delta\hat{Z}(5, 4)$	1.0	$\Delta P(4, 3)$	1.3	—	—
	10	U'	1.0	$P(1, 4)$	1.2	—	—
Total			49.3		48.6		43.5
24	1	V'	23.9	U'	28.5	$\Delta\hat{Z}(6, 3)$	23.0
	2	λ	11.5	$Z(6, 5)$	6.4	I_2	24.5
	3	$\Delta P(5, 4)$	3.4	$\Delta\hat{Z}(6, 5)$	4.8	$\Delta Z(5, 4)$	3.3
	4	$P(3, 2)$	2.4	$Z(5, 2)$	3.6	V^2	3.1
	5	$P(8, 3)$	2.1	$\Delta\hat{Z}(5, 4)$	4.1	$\Delta\eta_0$	1.4
	6	$P(5, 4)$	2.1	—	—	$P(3, 6)$	0.9
	7	U'	1.7	—	—	$P(4, 5)$	1.0
	8	$\Delta\hat{Z}(5, 4)$	1.8	—	—	Λ_T	1.0
	9	$\Delta\hat{Z}(5, 2)$	2.1	—	—	$\Delta H(2, 3)$	0.7
	10	$Z(7, 6)$	1.7	—	—	—	—
	11	$Z(5, 6)$	1.1	—	—	—	—
	12	$\Delta\hat{Z}(7, 6)$	1.1	—	—	—	—
	13	$\Delta\hat{Z}(6, 3)$	0.9	—	—	—	—
Total			55.8		47.4		58.9
36	1	V'	19.6	U'	23.4	$\Delta\hat{Z}(6, 3)$	17.9
	2	λ	12.1	$Z(6, 5)$	7.8	I_2	27.5
	3	$P(8, 5)$	3.1	$\Delta\hat{Z}(6, 5)$	5.3	$\Delta\hat{Z}(5, 4)$	2.6
	4	$\Delta Z(5, 4)$	3.7	$Z(5, 2)$	5.9	U'	2.6
	5	$P(5, 4)$	2.3	$\Delta Z(5, 4)$	4.8	$P(5, 3)$	1.3
	6	U'	2.1	$\Delta\hat{Z}(5, 2)$	1.8	—	—
	7	$\Delta\hat{Z}(5, 4)$	2.4	$P(6, 3)$	1.8	—	—
	8	$\Delta\hat{Z}(5, 2)$	2.7	$P(7, 2)$	2.0	—	—
	9	$P(8, 3)$	2.1	—	—	—	—
	10	$H(8, 5)$	1.4	—	—	—	—
Total			51.5		52.8		51.9

indicative of steering. For central pressure, the initial intensity of the cyclone is selected first, and the regression coefficient for this term suggests that intense cyclones will undergo little further intensification compared to initially weak cyclones.

An evaluation of the two experiments on independent data is shown in Table VII. The differences in root-mean-square (rms) errors for the two displacement components are rather small. However, for change in central pressure, the Exp. 2 equations yield the better results of the two experiments. It should be kept in mind, though, that actual analyses ("perfect" prognoses) were employed in Exp. 2 and that some loss of accuracy should be expected when using operational prognoses.
The equation results of Exps. 1 and 2 compare quite favorable with climatology (also shown in Table VII).

10. Atlantic Summer Cyclones

There were more sea-level pressure predictors selected in Exp. 1 for this area (see Table VIII) than in the same experiment for North America (cf Table VI). The only apparent steering/predictor combination was the 12-hr eastward displacement, with Z(5,2) and Z(5,4) selected as the first two predictors. For the change in central pressure, the 12-hr height change one grid interval to the west of the cyclone was selected first, while at intervals of 24 and 36 hr, the first predictor was the initial central pressure of the cyclone. For Exp. 2, steering was once again important, but did not contribute enough to be chosen first ahead of P(7,2) for 24-hr northward displacement and P(8,3) for 36-hr northward displacement. For the change in central pressure, a different predictor was selected first for all three forecast intervals. The 24-hr forecast height change one-grid interval to the east was selected first for 12-hr change in central pressure and then was selected second for both 24 and 36 hr.

On independent data (Table VII) Exp. 2 results were not appreciably better than Exp. 1, although both were superior to climatology.

11. European Summer Cyclones

The first two predictors selected in Exp. 1 [Table IX (a)] for northward displacement were H(6,3) and Z(5,4) for all three forecast intervals. Their regression coefficients are of opposite sign and, hence, the combination may be interpreted as a sort of steering term, although not as straightforward as the predictor combination of Z(7,2) and Z(4,3) which was selected for North America. For eastward displacement, the

TABLE VII

ROOT-MEAN-SQUARE ERRORS IN TESTS ON SUMMER CYCLONES, 1960

(independent sample)

Area	Forecast interval, hr	Exp. 1			Exp. 2			Climatology		
		N	E	D	N	E	D	N	E	D
North America (171 cases)	12	1.75	1.70	3.45	1.75	1.68	3.19	2.24	2.13	3.70
	24	2.97	3.04	5.43	2.78	2.82	4.91	3.80	3.79	5.68
	36	4.16	4.32	7.24	3.83	3.97	6.71	5.15	5.33	7.09
Atlantic (231 cases)	12	1.55	1.52	4.18	1.56	1.52	3.85	1.92	2.18	4.87
	24	2.46	2.82	5.58	2.41	2.75	5.46	3.42	3.75	7.11
	36	3.23	3.98	7.26	3.09	3.65	7.15	4.70	5.01	9.49
Europe (77 cases)	12	1.71	1.72	2.73	1.64	1.51	2.64	2.15	1.88	3.22
	24	2.83	2.81	4.78	2.59	2.34	4.05	3.59	3.03	5.48
	36	3.49	3.81	6.50	3.34	3.00	5.03	4.59	4.11	7.14
Eurasia (144 cases)	12	1.83	1.79	2.77	1.78	1.84	2.56	2.12	2.22	2.88
	24	2.88	2.63	3.43	2.78	2.78	3.17	3.34	3.85	3.67
	36	3.75	4.14	4.97	3.58	3.93	4.04	4.51	5.46	4.77
Asia (241 cases)	12	1.82	1.92	3.41	1.76	1.90	3.03	2.00	2.30	3.73
	24	2.60	2.74	4.86	2.36	2.77	4.22	3.07	3.80	5.92
	36	3.81	3.82	6.50	3.29	3.47	5.94	4.17	5.06	7.91
Pacific (162 cases)	12	1.44	1.31	3.86	1.48	1.51	3.55	2.15	2.17	4.70
	24	2.36	2.50	5.57	2.23	2.63	5.12	3.63	4.01	7.45
	36	3.45	3.86	7.30	3.09	3.82	6.85	4.88	5.98	9.48

TABLE VIII
PREDICTORS SELECTED BY SCREENING REGRESSION FOR ATLANTIC SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$ Predictor	$\hat{N}$ % red.	$\hat{E}$ Predictor	$\hat{E}$ % red.	$\hat{D}$ Predictor	$\hat{D}$ % red.
12	1	P(7, 2)	17.5	Z(5, 2)	16.7	ΔZ(4, 3)	6.5
	2	P(5, 4)	5.6	Z(5, 4)	19.3	I_1	4.2
	3	Z(6, 3)	7.3	Z(4, 3)	6.6	P(3, 2)	4.7
	4	Z(4, 3)	9.4	Z(2, 3)	2.7	P(6, 5)	2.5
	5	H(3, 6)	2.7	ΔP(4, 3)	1.5	ΔP(6, 3)	1.6
	6	ΔZ(5, 2)	2.1	Z(6, 3)	1.1	—	—
	7	ΔH(6, 3)	1.6	ΔH(5, 2)	1.3	—	—
	8	P(2, 5)	1.0	Z(7, 2)	1.0	—	—
	9	θ	0.7	I_2	1.0	—	—
	10	P(5, 2)	1.0	θ	0.9	—	—
	11	Z(3, 2)	0.8	—	—	—	—
	12	Z(8, 3)	0.9	—	—	—	—
	13	Z(7, 6)	1.0	—	—	—	—
Total			51.6		52.1		19.5
24	1	P(7, 2)	20.0	P(5, 2)	18.6	P(5, 3)	12.1
	2	P(5, 4)	7.7	P(6, 5)	14.2	ΔP(5, 2)	7.8
	3	Z(6, 3)	8.2	ΔP(4, 3)	2.2	H(4, 5)	5.1
	4	H(4, 3)	7.4	H(4, 3)	2.2	ΔP(6, 3)	2.9
	5	P(8, 5)	3.2	H(6, 5)	6.8	P(2, 3)	1.8
	6	H(4, 5)	3.3	ΔZ(7, 2)	2.0	P(5, 4)	1.9
	7	θ	2.0	Z(5, 4)	1.5	—	—
	8	Z(3, 2)	2.4	Z(5, 2)	1.3	—	—
	9	H(9, 1)	0.9	Z(6, 3)	1.3	—	—
	10	P(5, 2)	1.1	Z(7, 2)	1.1	—	—
	11	P(8, 3)	0.9	H(2, 3)	1.0	—	—
	12	H(6, 5)	0.6	—	—	—	—
	13	H(5, 4)	0.8	—	—	—	—
Total			58.5		52.2		31.6
36	1	P(8, 3)	21.1	P(5, 2)	18.7	P(5, 3)	22.0
	2	Z(4, 5)	7.7	P(6, 5)	13.8	ΔP(5, 2)	7.0
	3	Z(6, 3)	8.4	P(8, 5)	2.7	H(4, 5)	4.7
	4	Z(5, 4)	5.7	P(1, 1)	2.6	P(2, 3)	2.7
	5	P(8, 5)	3.1	H(4, 3)	1.7	P(6, 5)	2.0
	6	H(5, 4)	2.2	Z(6, 5)	4.8	ΔP(6, 3)	1.5
	7	P(4, 5)	2.6	ΔZ(7, 2)	1.6	—	—
	8	Z(3, 2)	2.4	ΔP(4, 3)	1.3	—	—
	9	θ	2.5	H(2, 3)	1.0	—	—
	10	H(6, 5)	1.3	θ	1.2	—	—
	11	P(5, 2)	1.2	Z(9, 1)	0.7	—	—
	12	—	—	H(9, 1)	1.4	—	—
Total			58.2		51.5		39.9

TABLE VIII

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\bar{E}$		$\dot{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	V′	18.3	U′	26.3	$\Delta\hat{Z}(6, 3)$	13.9
	2	P(7, 2)	10.3	V′	6.6	V	7.6
	3	P(8, 5)	3.7	P(6, 5)	4.3	I_1	6.7
	4	P(5, 4)	3.5	ΔP(4, 3)	2.8	$\Delta\eta_0$	2.7
	5	P(6, 3)	4.2	P(5, 2)	3.2	ΔP(4, 3)	1.4
	6	$\Delta\hat{Z}(6, 5)$	2.3	$\Delta\hat{Z}(6, 5)$	1.6	—	—
	7	$\Delta\hat{Z}(6, 3)$	1.9	H(6, 5)	1.6	—	—
	8	$\Delta\eta_0$	1.5	$\Delta\hat{Z}(5, 2)$	1.2	—	—
	9	ΔP(5, 2)	2.0	Z(5, 2)	1.2	—	—
	10	$\Delta\hat{Z}(8, 5)$	1.8	Z(5, 4)	1.8	—	—
	11	η_0	1.1	ΔZ(5, 2)	1.5	—	—
	12	Z(3, 2)	1.0	$\Delta\hat{Z}(5, 4)$	1.1	—	—
	13	H(7, 2)	1.8	η_5	0.8	—	—
	14	—	—	P(6, 3)	1.0	—	—
Total			53.4		55.0		32.3
24	1	P(7, 2)	20.0	U′	24.1	V	17.4
	2	V′	9.2	V′	8.4	$\Delta\hat{Z}(6, 3)$	12.2
	3	P(8, 5)	5.8	P(6, 5)	5.8	I_2	10.3
	4	P(5, 4)	5.4	P(5, 2)	4.6	$\Delta\eta_0$	2.8
	5	η_5	5.2	$\Delta\hat{Z}(5, 2)$	2.9	η_0	1.9
	6	$\Delta\hat{Z}(8, 5)$	2.2	H(6, 5)	2.0	H(1, 1)	1.6
	7	ΔP(5, 2)	1.7	$\Delta\hat{Z}(6, 5)$	2.8	$\Delta\hat{Z}(6, 3)$	1.2
	8	P(6, 3)	1.8	Z(5, 2)	3.3	$\Delta\hat{Z}(6, 5)$	0.8
	9	P(2, 5)	1.4	$\Delta\hat{Z}(5, 4)$	2.1	ΔP(5, 2)	1.0
	10	U′	1.1	P(6, 3)	1.1	—	—
	11	$\Delta\hat{Z}(6, 5)$	1.2	ΔA_T	0.8	—	—
	12	Z(8, 3)	0.9	P(7, 2)	0.7	—	—
	13	Z(3, 2)	1.8	P(5, 3)	1.0	—	—
Total			57.7		59.6		49.2
36	1	P(8, 3)	21.1	U′	20.0	P(5, 3)	22.0
	2	V′	8.7	V′	7.6	$\Delta\hat{Z}(6, 3)$	18.4
	3	ΔI_T	4.1	P(6, 5)	6.2	U′	6.8
	4	Z(4, 5)	3.3	P(5, 2)	5.9	P(5, 4)	2.3
	5	Z(7, 2)	4.6	$\Delta\hat{Z}(5, 2)$	3.1	P(2, 3)	1.7
	6	P(8, 5)	3.4	P(8, 5)	3.0	$\Delta\hat{Z}(6, 5)$	1.2
	7	$\Delta\hat{Z}(8, 5)$	3.0	—	—	ΔP(4, 3)	1.2
	8	$\Delta\hat{Z}(7, 2)$	2.2	—	—	Z(6, 3)	1.4
	9	$\Delta\hat{Z}(6, 5)$	1.4	—	—	—	—
	10	Z(5, 4)	1.6	—	—	—	—
	11	Z(6, 3)	1.5	—	—	—	—
	12	$\Delta\hat{Z}(6, 3)$	1.3	—	—	—	—
	13	$\Delta\hat{Z}(5, 4)$	1.8	—	—	—	—
Total			58.0		45.8		55.0

TABLE IX
PREDICTORS SELECTED BY SCREENING REGRESSION FOR EUROPEAN SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	H(6, 3)	9.0	P(6, 5)	6.2	I_2	9.1
	2	Z(5, 4)	16.0	ΔP(4, 3)	3.5	ΔZ(4, 3)	6.7
	3	H(3, 2)	4.6	ΔP(5, 2)	4.9	P(3, 2)	2.9
	4	Z(5, 2)	3.5	P(5, 2)	2.7	Z(5, 4)	2.3
	5	ΔP(5, 4)	2.9	Z(8, 3)	2.6	ΔP(5, 4)	3.3
	6	P(8, 5)	2.6	Z(5, 2)	1.8	Z(5, 2)	2.6
	7	ΔP(5, 2)	2.4	Z(5, 4)	5.5	—	—
	8	H(5, 4)	1.6	Z(6, 3)	2.4	—	—
	9	Z(7, 2)	1.8	I_1	2.2	—	—
	10	—	—	Z(7, 2)	2.8	—	—
Total			44.4		34.6		27.9
24	1	H(6, 3)	10.1	Z(6, 5)	7.9	P(5, 3)	16.6
	2	Z(5, 4)	19.7	Z(5, 2)	7.9	ΔP(5, 4)	6.6
	3	H(3, 2)	5.4	Z(6, 3)	10.1	P(6, 5)	8.1
	4	P(8, 5)	3.8	ΔP(4, 3)	1.7	ΔZ(5, 2)	2.5
	5	Z(5, 2)	3.1	P(1, 7)	1.6	ΔP(2, 3)	2.0
	6	—	—	I_1	1.1	Z(5, 4)	1.7
	7	—	—	Z(7, 2)	1.8	Z(1, 1)	1.8
	8	—	—	—	—	P(1, 4)	1.5
Total			42.1		32.1		40.8
36	1	H(6, 3)	8.6	Z(6, 5)	8.8	P(5, 3)	25.9
	2	Z(5, 4)	19.2	Z(5, 2)	11.4	P(6, 5)	5.8
	3	H(3, 2)	4.6	Z(6, 3)	8.5	ΔP(5, 4)	4.5
	4	P(8, 5)	4.1	ΔZ(4, 3)	3.3	ΔP(2, 3)	2.0
	5	Z(5, 2)	2.2	ΔZ(7, 6)	2.6	ΔP(3, 6)	2.3
	6	H(7, 2)	1.8	Z(2, 3)	2.3	Z(9, 7)	1.8
	7	ΔP(5, 4)	1.5	Z(7, 2)	1.9	ΔZ(5, 2)	1.4
	8	ΔP(3, 6)	1.2	I_1	1.7	P(1, 4)	0.9
	9	ΔP(7, 2)	1.3	ΔH(5, 2)	1.8	Z(5, 4)	1.0
	10	P(9, 7)	0.9	—	—	Z(1, 1)	2.3
	11	θ	0.9	—	—	—	—
	12	P(5, 6)	1.1	—	—	—	—
Total			47.4		42.3		47.9

TABLE IX

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	V'	18.2	U'	17.5	$\Delta\hat{Z}(6, 3)$	13.1
	2	$\Delta P(5, 4)$	4.9	$\Delta\hat{Z}(5, 2)$	5.1	I_2	15.1
	3	$Z(7, 2)$	4.3	V	4.2	$\Delta\eta_0$	4.9
	4	$\Delta\hat{Z}(7, 2)$	4.5	$Z(6, 5)$	1.5	$\Delta\hat{Z}(5, 4)$	3.3
	5	$Z(5, 4)$	6.1	$Z(5, 2)$	1.6	$Z(5, 4)$	2.9
	6	$\Delta\hat{Z}(5, 4)$	3.8	$Z(6, 3)$	4.9	$Z(2, 3)$	2.7
	7	$\Delta Z(5, 2)$	2.2	I_1	1.6	—	—
	8	$P(5, 4)$	1.8	$\Delta P(3, 2)$	1.7	—	—
	9	$P(5, 2)$	4.1	$\Delta\hat{Z}(7, 2)$	1.9	—	—
	10	$\Delta\hat{Z}(6, 3)$	1.5	—	—	—	—
Total			51.4		40.0		42.0
24	1	V'	21.4	U'	13.3	$\Delta\hat{Z}(5, 4)$	18.0
	2	$\Delta\hat{Z}(5, 4)$	7.0	$\Delta\hat{Z}(5, 2)$	6.5	U'	13.4
	3	$P(5, 4)$	5.7	V	5.8	I_2	8.5
	4	$P(5, 2)$	5.9	$Z(6, 5)$	3.0	$\Delta\hat{Z}(6, 3)$	14.3
	5	$\Delta\hat{Z}(6, 3)$	5.4	$Z(5, 2)$	2.0	η_5	1.2
	6	U'	3.8	$Z(6, 3)$	4.6	$P(2, 3)$	1.5
	7	$\Delta\hat{Z}(5, 2)$	4.0	—	—	—	—
	8	$Z(7, 2)$	2.7	—	—	—	—
	9	$H(3, 2)$	3.4	—	—	—	—
	10	$\Delta\hat{Z}(7, 2)$	2.1	—	—	—	—
Total			61.4		35.2		56.9
36	1	V'	17.6	U'	14.8	$P(5, 3)$	25.9
	2	$\Delta\hat{Z}(5, 4)$	7.8	$\Delta\hat{Z}(5, 2)$	9.0	$\Delta\hat{Z}(6, 3)$	17.4
	3	$P(5, 4)$	5.1	V^2	5.5	$\Delta\hat{Z}(5, 4)$	7.9
	4	U'	5.2	$Z(6, 5)$	3.1	$P(6, 5)$	5.7
	5	$\Delta\hat{Z}(5, 2)$	6.2	$Z(5, 2)$	4.2	I_2	2.4
	6	$Z(8, 3)$	4.1	$Z(6, 3)$	5.0	U'	2.7
	7	$H(3, 2)$	4.2	I_1	1.8	η_5	1.1
	8	$Z(6, 3)$	3.1	$\Delta\hat{Z}(6, 5)$	2.0	$\Delta P(3, 6)$	0.9
	9	$\Delta\hat{Z}(6, 3)$	1.6	—	—	$P(1, 4)$	0.9
	10	$Z(5, 4)$	1.4	—	—	$\Delta\hat{Z}(3, 2)$	1.2
	11	—	—	—	—	$Z(9, 7)$	0.9
	12	—	—	—	—	$Z(1, 1)$	0.6
	13	—	—	—	—	$Z(5, 4)$	1.1
Total			56.3		45.4		68.7

predictor combination of Z(6,5) and Z(5,2) was selected for 24- and 36-hr intervals and can be considered as representing steering. For central pressure, the initial intensity (12 hr) and the initial central pressure (24 and 36 hr) were selected first and related initially deep or intense cyclones to little further intensification.

With Exp. 2 predictors, the steering terms were selected first for all displacement predictands [Table IX (b)]. Note that the percent reduction of variance is much larger for Exp. 2 than Exp. 1 in the cases of northward displacement and change in central pressure.

On independent data (Table VII) for Europe, the rms errors are smaller for Exp. 2 than Exp. 1 for all nine predictands, with the most impressive differences being 36-hr eastward displacement and 24- and 36-hr change in pressure. Both experiments yielded results superior to climatology.

12. Eurasian Summer Cyclones

The predictors selected for Exp. 1 [Table X (a)] show a similarity to those selected for North American cyclones [see Table VI (a)]. Except for 12-hr northward displacement, a steering predictor combination is selected first: Z(7,2) and Z(4,3) for northward displacement, and the combination of Z(6,5) and Z(5,2) for eastward displacement. For central pressure change, the initial intensity and the initial central pressure are of importance.

Using Exp. 2 predictors, the explicit steering components U′ and V′ are selected first for all displacement predictands; this was also the case with North America. The 24-hr forecast of 500-mb height change one grid interval to the east of the cyclone was selected first for 24-hr change in central pressure and second for that predictand for 12- and 36-hr intervals.

On independent data the differences between the two experiments seem small; however, there is evidence of considerable improvement over climatology.

13. Asian Summer Cyclones

With Exp. 1 predictors [Table XI (a)] we find that P(8,3) is selected first for all three forecast intervals for northward displacement. This predictor, located three grid intervals to the east of the cyclone, has a regression coefficient (see the Appendix) such that high pressure in that region indicates large northward cyclone displacement. This relationship is apparently strong enough to have P(8,3) selected first in preference

TABLE X
PREDICTORS SELECTED BY SCREENING REGRESSION FOR EURASIAN SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	ΔP(5, 2)	5.7	Z(6, 5)	11.7	I_1	9.2
	2	ΔP(6, 3)	4.3	Z(5, 2)	8.3	P(4, 3)	2.9
	3	H(1, 7)	3.2	Z(5, 4)	5.6	ΔZ(5, 2)	3.1
	4	Z(4, 3)	4.2	Z(4, 3)	4.0	H(1, 7)	3.8
	5	Z(6, 3)	12.8	—	—	Z(8, 5)	4.8
	6	Z(5, 4)	3.1	—	—	—	—
Total			33.3		29.6		23.8
24	1	Z(7, 2)	8.6	Z(6, 5)	15.2	I_1	11.0
	2	Z(4, 3)	14.7	Z(5, 2)	15.2	Z(8, 5)	4.6
	3	Z(6, 3)	8.5	Z(5, 4)	4.5	Z(5, 2)	6.1
	4	Z(2, 3)	2.4	Z(4, 3)	2.3	ΔZ(5, 2)	3.1
	5	ΔZ(5, 4)	2.1	P(2, 3)	1.8	Z(2, 5)	2.9
	6	—	—	H(3, 2)	1.6	H(5, 4)	3.9
	7	—	—	P(9, 7)	1.1	ΔP(5, 4)	3.0
	8	—	—	ΔP(4, 3)	1.0	—	—
	9	—	—	Z(8, 5)	0.9	—	—
	10	—	—	P(6, 5)	0.9	—	—
	11	—	—	P(5, 3)	0.9	—	—
	12	—	—	P(6, 3)	1.4	—	—
	13	—	—	P(7, 2)	1.6	—	—
Total			36.3		48.4		34.6
36	1	Z(7, 2)	9.2	Z(6, 5)	17.5	P(5, 3)	15.8
	2	Z(4, 3)	14.4	Z(5, 2)	15.7	Z(8, 5)	3.9
	3	Z(6, 3)	6.3	H(5, 4)	3.5	P(5, 2)	5.7
	4	H(2, 5)	3.8	P(2, 3)	2.7	H(1, 7)	3.7
	5	Z(5, 4)	3.7	—	—	ΔZ(4, 3)	2.3
	6	ΔZ(5, 4)	2.2	—	—	—	—
	7	I_2	1.8	—	—	—	—
	8	Z(8, 5)	1.8	—	—	—	—
Total			43.2		39.4		31.4

TABLE X

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	V′	20.2	U′	20.2	I_1	9.2
	2	H(1, 7)	3.6	A_T	4.1	$\Delta\hat{Z}$(6, 3)	12.2
	3	ΔP(5, 2)	2.4	Z(6, 5)	4.1	U′	5.1
	4	Z(5, 4)	2.3	P(2, 3)	2.7	ΔZ(1, 1)	2.8
	5	Z(6, 3)	2.9	—	—	Z(2, 5)	2.4
	6	$\Delta\hat{Z}$(5, 4)	2.0	—	—	—	—
	7	$\Delta\hat{Z}$(5, 2)	2.3	—	—	—	—
Total			35.7		31.1		31.7
24	1	V′	25.2	U′	27.2	$\Delta\hat{Z}$(6, 3)	12.9
	2	H(1, 7)	4.5	Z(6, 5)	4.9	I_2	19.4
	3	$\Delta\hat{Z}$(5, 4)	2.4	$\Delta\hat{Z}$(5, 2)	3.0	U′	5.9
	4	$\Delta\hat{Z}$(5, 2)	2.3	A_T	3.2	$\Delta\hat{Z}$(5, 4)	3.0
	5	Z(5, 4)	2.4	P(2, 3)	2.7	η_5	3.4
	6	Z(8, 3)	3.4	P(5, 3)	2.3	Z(2, 5)	2.0
	7	—	—	—	—	$\Delta\hat{Z}$(3, 6)	1.7
	8	—	—	—	—	H(6, 3)	1.4
	9	—	—	—	—	$\Delta\eta_5$	1.4
Total			40.2		43.3		51.1
36	1	V′	22.6	U′	27.1	P(5, 3)	15.8
	2	$\Delta\hat{Z}$(5, 4)	5.6	Z(6, 5)	6.3	$\Delta\hat{Z}$(6, 3)	13.3
	3	P(5, 4)	3.6	$\Delta\hat{Z}$(5, 2)	3.5	I_2	8.1
	4	Z(8, 3)	3.3	Z(5, 2)	3.1	U′	4.2
	5	P(7, 2)	4.4	Z(8, 5)	2.0	$\Delta\hat{Z}$(5, 4)	3.4
	6	I_2	2.0	A_T	1.7	η_5	2.9
	7	$\Delta\hat{Z}$(7, 2)	2.1	P(2, 3)	1.7	Z(2, 5)	1.4
	8	H(2, 5)	1.6	P(5, 3)	1.4	Z(8, 5)	2.1
	9	H(5, 4)	2.3	H(6, 5)	1.8	—	—
	10	ΔZ(5, 4)	1.5	—	—	—	—
	11	$\Delta\hat{Z}$(5, 2)	1.3	—	—	—	—
	12	P(6, 3)	1.5	—	—	—	—
Total			51.8		48.6		51.2

TABLE XI
PREDICTORS SELECTED BY SCREENING REGRESSION FOR ASIAN
SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\bar{N}$		$\bar{E}$		$\bar{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	P(8, 3)	15.0	ΔP(6, 3)	6.2	ΔP(5, 2)	5.1
	2	ΔP(5, 4)	6.2	P(5, 2)	4.7	P(5, 3)	6.5
	3	H(6, 3)	3.2	P(6, 3)	4.8	ΔP(6, 3)	3.2
	4	Z(4, 5)	6.8	Z(6, 5)	2.1	ΔZ(5, 4)	1.3
	5	Z(3, 2)	1.5	Z(5, 2)	6.2	—	—
	6	Z(7, 2)	2.2	θ	1.6	—	—
	7	—	—	ΔZ(4, 3)	1.8	—	—
	8	—	—	Z(5, 4)	2.1	—	—
	9	—	—	Z(4, 3)	1.2	—	—
Total			34.9		30.7		16.1
24	1	P(8, 3)	20.2	θ	6.9	P(5, 3)	7.6
	2	ΔP(5, 4)	5.3	Z(6, 5)	15.5	ΔP(5, 2)	9.9
	3	H(6, 3)	3.7	Z(5, 2)	5.6	ΔP(6, 3)	4.7
	4	Z(5, 4)	9.4	ΔP(6, 3)	3.0	ΔH(3, 2)	1.3
	5	P(6, 3)	2.1	ΔZ(4, 3)	3.0	H(1, 7)	0.9
	6	Z(6, 5)	1.6	Z(6, 3)	1.9	H(7, 2)	1.5
	7	θ	1.4	Z(7, 2)	1.1	Z(5, 4)	3.5
	8	Z(3, 2)	2.1	Z(1, 1)	1.3	ΔP(4, 3)	1.2
	9	Z(8, 5)	1.2	Z(4, 5)	0.8	—	—
	10	H(1, 7)	1.1	Z(4, 3)	1.5	—	—
Total			48.1		40.6		30.6
36	1	P(8, 3)	21.3	θ	8.6	P(5, 3)	10.8
	2	θ	6.6	Z(6, 5)	15.9	ΔP(5, 2)	8.2
	3	P(5, 3)	4.7	Z(5, 2)	6.3	ΔP(6, 3)	4.8
	4	H(4, 5)	1.6	ΔP(6, 3)	2.3	ΔH(3, 2)	1.5
	5	Z(7, 2)	5.2	P(2, 3)	2.1	H(1, 7)	1.5
	6	Z(8, 5)	3.2	H(5, 2)	3.4	H(7, 2)	1.4
	7	Z(3, 2)	3.5	ΔP(2, 3)	1.4	Z(5, 4)	2.9
	8	ΔP(3, 6)	0.8	P(6, 3)	0.9	—	—
	9	Z(6, 3)	0.8	ΔZ(4, 3)	0.7	—	—
	10	Z(5, 4)	2.2	Z(4, 5)	0.6	—	—
	11	—	—	Z(7, 2)	0.6	—	—
	12	—	—	H(6, 3)	1.1	—	—
Total			49.9		43.9		31.1

TABLE XI

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	P(8, 3)	15.0	U′	15.8	$\Delta\hat{Z}$(6, 3)	9.9
	2	V′	6.8	A_T	4.3	P(5, 3)	7.5
	3	Z(7, 2)	4.9	ΔP(6, 3)	4.5	ΔP(5, 2)	4.1
	4	Z(4, 5)	4.1	ΔZ(4, 3)	2.0	$\Delta\hat{Z}$(5, 4)	2.1
	5	$\Delta\hat{Z}$(7, 2)	2.5	ΔZ(5, 2)	1.1	ΔZ(5, 4)	1.7
	6	ΔP(5, 4)	2.7	Z(6, 5)	1.4	P(6, 3)	1.6
	7	P(5, 4)	1.3	Z(4, 3)	2.1	$\Delta\eta_0$	1.7
	8	Z(9, 1)	1.1	$\Delta\hat{Z}$(6, 5)	1.9	—	—
	9	$\Delta\hat{Z}$(6, 5)	1.0	—	—	—	—
Total			39.4		33.1		28.6
24	1	P(8, 3)	20.2	U′	17.7	$\Delta\hat{Z}$(6, 3)	13.4
	2	$\Delta\hat{Z}$(6, 5)	7.8	ΔP(6, 3)	4.0	P(5, 3)	11.5
	3	V′	5.9	P(5, 2)	3.3	ΔP(5, 2)	6.1
	4	θ	4.2	P(6, 5)	6.6	$\Delta\hat{Z}$(6, 5)	4.4
	5	P(5, 4)	2.7	$\Delta\hat{Z}$(5, 2)	3.3	P(6, 3)	1.3
	6	$\Delta\hat{Z}$(5, 4)	1.8	P(6, 3)	1.9	$\Delta\eta_0$	2.1
	7	$\Delta\hat{Z}$(5, 2)	2.6	$\Delta\hat{Z}$(6, 3)	1.8	P(8, 3)	1.5
	8	U′	1.4	V′	1.8	$\Delta\hat{Z}$(7, 6)	0.9
	9	Z(8, 5)	1.7	Z(1, 1)	1.2	Z(5, 4)	0.8
	10	Z(3, 2)	1.6	$\Delta\hat{Z}$(5, 4)	0.8	H(7, 2)	1.1
	11	P(7, 2)	1.1	ΔH(5, 4)	0.7	$\Delta\hat{Z}$(5, 4)	1.1
	12	$\Delta\hat{Z}$(8, 5)	1.4	$\Delta\hat{Z}$(6, 5)	0.7	—	—
	13	—	—	Z(6, 5)	0.8	—	—
	14	—	—	H(5, 4)	3.2	—	—
Total			52.4		47.8		44.2
36	1	P(8, 3)	21.3	U′	17.8	$\Delta\hat{Z}$(6, 3)	11.0
	2	$\Delta\hat{Z}$(6, 5)	6.7	$\Delta\hat{Z}$(5, 2)	3.2	P(5, 3)	15.0
	3	V′	4.8	Z(6, 5)	4.0	$\Delta\hat{Z}$(6, 5)	5.3
	4	θ	6.5	Z(5, 2)	7.6	ΔP(5, 2)	5.0
	5	P(5, 4)	1.9	$\Delta\hat{Z}$(6, 5)	3.6	Z(6, 5)	1.5
	6	$\Delta\hat{Z}$(5, 4)	1.4	$\Delta\hat{Z}$(7, 2)	2.9	H(7, 2)	3.2
	7	$\Delta\hat{Z}$(5, 2)	2.1	$\Delta\hat{Z}$(5, 4)	2.6	—	—
	8	U′	1.2	θ	2.0	—	—
	9	Z(8, 5)	2.2	P(2, 3)	1.2	—	—
	10	H(5, 4)	2.6	H(5, 2)	1.6	—	—
	11	Z(6, 3)	2.8	—	—	—	—
	12	$\Delta\hat{Z}$(8, 5)	1.4	—	—	—	—
	13	Z(3, 2)	1.4	—	—	—	—
Total			56.3		46.5		41.0

to V′ in Exp. 2 [Table XI (b)]. Exp.1 eastward displacement for 24 and 36 hr presents a curious situation in which the cyclone latitude is selected first and Z(6,5) is selected second. Although the latitude has a higher correlation with eastward displacement than has Z(6,5) (by definition of the selection process of the screening procedure), the percent reduction of variance contributed by the second predictor is much larger than the first. This means that although the correlation between the predictand and Z(6,5) is low, it becomes high when considered in combination with the latitude. The synoptic explanation for this particular predictor combination is not at all clear-cut.

On independent data, there is an indication of slight improvement in results using Exp. 2 as opposed to Exp. 1. Here again, even the simple predictors of Exp.1 yield results superior to climatology.

14. Pacific Summer Cyclones

Steering is an important consideration in this area. For Exp.1 [Table XII (a)] the predictor combinations Z(7,2) and Z(5,4) for northward displacement and Z(5,2) and Z(6,5) for eastward displacement occur often. With Exp. 2 predictors, U′ and V′ are prominant. For central pressure, the same predictors are chosen first in both experiments.

Results on independent data show there is little advantage in using Exp. 2 rather than Exp. 1, although both are considerably superior to climatology.

15. Atlantic Winter Cyclones

In this analysis, and for Eurasian and Pacific winter cyclones as well, the (K,L)-reference point for the cyclone is (5,4) instead of (5,3). For Exp. 1 [Table XIII (a)], the first selected predictor for northward displacement for all three forecast intervals is P(5,6), which is two grid intervals north of the cyclone location and has a regression coefficient which is negative. This implies that lower pressures to the north of a cyclone are conducive to northward cyclone displacement, or conversely, higher pressures to the north are inhibitive to northward cyclone displacement. The first two predictors selected for eastward displacement for two of the three forecast intervals are Z(5,2) and Z(7,6) with Z(6,5) being selected second for the 12-hr lag.

Although these predictor combinations are suggestive of steering components, the characteristic increase in percent reduction of variance with the selection of the second predictor is missing. For the central pressure predictand the initial intensity

TABLE XII
PREDICTORS SELECTED BY SCREENING REGRESSION FOR
PACIFIC SUMMER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
	1	ΔP(5, 4)	7.4	Z(5, 2)	16.9	ΔP(5, 2)	19.2
	2	P(7, 2)	9.0	Z(6, 5)	25.5	I_1	6.5
	3	P(3, 2)	5.5	P(6, 3)	3.7	ΔP(5, 4)	4.3
	4	ΔP(3, 2)	4.1	P(4, 3)	3.7	ΔH(6, 3)	3.1
	5	H(6, 3)	3.6	Z(5, 4)	1.5	ΔZ(4, 3)	1.9
12	6	H(4, 3)	10.4	P(2, 3)	1.8	—	—
	7	Z(5, 4)	3.7	H(4, 3)	1.2	—	—
	8	Z(6, 3)	3.2	H(2, 3)	1.2	—	—
	9	Z(8, 3)	1.8	H(5, 2)	0.7	—	—
	10	H(5, 4)	1.5	θ	1.1	—	—
	11	—	—	ΔP(3, 2)	0.9	—	—
Total			50.2		58.2		35.0
	1	Z(7, 2)	10.5	P(7, 6)	20.2	ΔP(5, 2)	26.2
	2	Z(5, 4)	20.4	Z(5, 2)	11.1	I_2	9.6
	3	Z(6, 3)	10.7	Z(6, 5)	17.4	H(5, 2)	5.0
	4	Z(3, 2)	5.1	Z(6, 3)	2.4	ΔP(5, 4)	3.2
	5	P(7, 6)	2.7	Z(4, 3)	2.0	H(5, 4)	2.8
24	6	H(3, 2)	1.6	θ	1.2	ΔP(4, 3)	1.7
	7	P(3, 6)	1.3	Z(2, 3)	1.0	ΔH(5, 2)	1.5
	8	ΔH(7, 2)	1.2	Z(5, 4)	1.4	ΔZ(4, 5)	0.7
	9	ΔH(5, 4)	1.0	P(6, 3)	1.1	H(1, 1)	0.6
	10	H(2, 5)	0.7	H(5, 2)	1.8	ΔH(6, 3)	0.7
	11	Z(1, 4)	1.3	—	—	ΔZ(7, 2)	0.9
	12	Z(6, 5)	0.9	—	—	—	—
Total			57.4		59.6		52.9
	1	Z(7, 2)	13.3	P(7, 6)	22.4	Z(5, 2)	31.4
	2	Z(5, 4)	19.8	Z(5, 2)	11.2	ΔP(5, 2)	9.7
	3	Z(6, 3)	8.8	Z(6, 5)	15.6	I_1	6.2
	4	P(3, 2)	4.5	Z(4, 3)	2.0	ΔZ(4, 3)	2.9
	5	P(8, 5)	2.8	Z(6, 3)	1.6	Z(5, 4)	1.6
36	6	P(2, 5)	2.1	P(1, 1)	1.4	ΔP(7, 2)	2.2
	7	Z(2, 5)	1.1	ΔP(3, 2)	1.0	ΔH(4, 5)	0.8
	8	Z(1, 4)	1.1	H(4, 5)	0.9	H(1, 1)	0.9
	9	—	—	ΔP(5, 2)	0.7	P(5, 3)	0.9
	10	—	—	P(6, 3)	0.8	ΔH(4, 3)	1.0
	11	—	—	H(5, 2)	1.4	P(7, 2)	0.8
	12	—	—	—	—	ΔP(6, 3)	1.1
Total			53.5		59.0		59.5

TABLE XII

(b) Exp. 2

Forecast interval, hr	Order of selection	$\bar{N}$ Predictor	$\bar{N}$ % red.	$\bar{E}$ Predictor	$\bar{E}$ % red.	$\bar{D}$ Predictor	$\bar{D}$ % red.
12	1	V'	23.8	U'	30.7	$\Delta P(5, 2)$	19.2
	2	$\Delta\bar{Z}(6, 5)$	5.4	A_T	8.1	$\Delta\bar{Z}(6, 3)$	6.9
	3	$P(7, 2)$	5.3	V'	5.5	I_1	9.0
	4	$P(3, 2)$	4.9	$Z(6, 5)$	3.6	$\Delta\bar{Z}(5, 4)$	4.7
	5	$Z(4, 5)$	1.9	$Z(5, 2)$	3.6	V	3.3
	6	$H(8, 3)$	3.0	$\Delta Z(6, 5)$	2.6	$\Delta P(4, 3)$	1.4
	7	$\Delta P(5, 4)$	1.9	$\Delta\bar{Z}(7, 2)$	1.8	$P(5, 4)$	1.1
	8	$\Delta\bar{Z}(6, 3)$	1.6	$\Delta\bar{Z}(5, 4)$	1.5	$\Delta Z(5, 2)$	1.0
	9	U'	1.6	θ	1.0	$H(9, 4)$	1.1
	10	$\Delta H(4, 3)$	1.0	$P(2, 3)$	1.0	—	—
	11	$P(5, 4)$	0.9	—	—	—	—
	12	$P(6, 3)$	1.4	—	—	—	—
Total			52.7		59.4		47.7
24	1	V'	22.4	U'	32.7	$\Delta P(5, 2)$	26.2
	2	U'	5.8	V'	7.5	V	10.4
	3	$\Delta\bar{Z}(5, 2)$	8.2	$Z(6, 5)$	5.3	I_2	9.1
	4	$\Delta\bar{Z}(5, 4)$	5.8	$Z(4, 3)$	6.2	$\Delta\bar{Z}(6, 3)$	9.4
	5	$P(7, 2)$	3.0	$\Delta\bar{Z}(6, 5)$	6.1	$\Delta\bar{Z}(5, 4)$	3.8
	6	$P(5, 4)$	4.1	$\Delta\bar{Z}(5, 4)$	3.8	$H(3, 2)$	1.1
	7	$\Delta\bar{Z}(6, 3)$	2.6	$\Delta\bar{Z}(6, 3)$	1.9	$Z(5, 4)$	1.1
	8	$Z(6, 3)$	1.3	η_0	1.6	$\Delta P(4, 3)$	1.3
	9	$Z(5, 4)$	5.2	$\Delta\bar{Z}(5, 2)$	1.2	—	—
	10	$\Delta Z(6, 5)$	1.2	$Z(5, 2)$	1.3	—	—
	11	θ	1.0	A_T	0.8	—	—
	12	$P(3, 2)$	0.7	—	—	—	—
	13	$P(2, 5)$	0.8	—	—	—	—
	14	$\Delta Z(5, 2)$	0.6	—	—	—	—
	15	$\Delta Z(6, 3)$	0.7	—	—	—	—
Total			63.4		68.4		62.4
36	1	V	17.2	U'	31.1	$Z(5, 2)$	31.4
	2	$P(8, 3)$	9.4	$P(7, 6)$	7.5	$\Delta\bar{Z}(6, 3)$	11.6
	3	$P(3, 2)$	6.8	V'	6.0	I_2	9.8
	4	$\Delta\bar{Z}(6, 5)$	4.6	$\Delta Z(4, 3)$	3.2	V	6.4
	5	V'	3.8	η_0	3.8	$\Delta P(5, 2)$	3.6
	6	$\Delta\bar{Z}(5, 2)$	2.7	$Z(6, 5)$	3.1	$\Delta Z(4, 3)$	2.8
	7	$P(2, 5)$	1.6	$\Delta\bar{Z}(6, 5)$	3.7	$H(3, 2)$	1.1
	8	$Z(7, 2)$	1.1	$Z(4, 3)$	4.9	$\Delta\bar{Z}(5, 4)$	1.4
	9	$Z(4, 5)$	3.5	$Z(2, 3)$	1.6	$H(5, 4)$	0.8
	10	$Z(8, 5)$	1.7	$\Delta\bar{Z}(6, 3)$	1.3	$\Delta Z(4, 5)$	0.7
	11	$\Delta\bar{Z}(8, 5)$	1.6	$\Delta\bar{Z}(5, 4)$	1.7	$\Delta Z(4, 3)$	0.8
	12	$H(5, 4)$	2.0	$\Delta\bar{Z}(5, 2)$	0.8	—	—
	13	$\Delta\bar{Z}(5, 4)$	1.5	$P(1, 7)$	0.6	—	—
	14	$Z(6, 3)$	1.2	—	—	—	—
	15	$Z(5, 4)$	2.7	—	—	—	—
Total			61.4		69.3		70.4

TABLE XIII
PREDICTORS SELECTED BY SCREENING REGRESSION FOR
ATLANTIC WINTER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	P(5, 6)	19.6	Z(5, 2)	35.7	I_1	12.2
	2	P(8, 3)	11.5	Z(6, 5)	16.8	ΔP(5, 4)	16.8
	3	Z(6, 5)	4.3	Z(5, 4)	2.7	P(6, 3)	3.8
	4	Z(4, 5)	8.1	Z(5, 6)	3.3	P(5, 6)	2.9
	5	Z(6, 3)	4.1	Z(4, 3)	1.4	P(2, 5)	2.1
	6	ΔP(4, 5)	2.4	Z(7, 2)	2.0	P(5, 4)	1.2
	7	P(5, 4)	1.3	ΔH(5, 4)	0.7	Z(4, 5)	1.2
	8	P(3, 2)	0.9	λ	0.5	Z(2, 3)	1.4
	9	ΔP(5, 2)	0.8	Z(2, 3)	0.5	ΔZ(1, 4)	1.0
	10	H(6, 3)	1.0	H(6, 5)	0.4	—	—
	11	H(7, 2)	0.7	H(5, 2)	0.6	—	—
Total			54.7		64.6		42.6
24	1	P(5, 6)	25.3	Z(5, 2)	34.4	P(5, 4)	23.8
	2	P(8, 3)	12.9	Z(7, 6)	16.9	Z(5, 6)	14.2
	3	Z(6, 3)	4.8	Z(5, 6)	3.3	H(5, 2)	5.8
	4	Z(4, 5)	3.7	Z(4, 5)	4.2	ΔP(5, 4)	2.3
	5	Z(6, 5)	5.3	ΔZ(4, 3)	1.1	I_2	4.2
	6	ΔP(4, 5)	1.6	I_2	1.0	P(2, 5)	2.3
	7	Z(8, 5)	1.6	H(8, 5)	0.8	P(3, 2)	0.8
	8	P(3, 2)	1.4	P(7, 2)	0.8	ΔP(4, 3)	0.7
	9	P(3, 6)	0.7	Z(6, 5)	0.5	Z(4, 5)	0.9
	10	—	—	Z(5, 4)	0.6	ΔP(7, 2)	0.8
	11	—	—	ΔZ(9, 7)	0.4	H(9, 7)	0.5
Total			57.3		64.0		56.3
	1	P(5, 6)	24.4	Z(5, 2)	30.0	P(5, 4)	35.0
	2	Z(6, 3)	13.5	Z(7, 6)	15.7	Z(5, 6)	12.2
	3	P(8, 5)	5.9	Z(8, 5)	2.5	H(5, 2)	6.9
	4	Z(4, 5)	4.6	P(6, 3)	1.5	ΔP(4, 3)	2.1
	5	Z(9, 1)	2.2	ΔZ(4, 3)	1.3	Z(4, 5)	1.3
	6	Z(3, 2)	1.1	H(7, 6)	0.8	P(2, 5)	1.2
	7	ΔP(4, 5)	0.8	H(5, 6)	1.0	ΔP(3, 2)	0.7
	8	P(3, 6)	1.0	Z(4, 5)	1.7	Z(7, 6)	0.7
	9	θ	0.6	P(5, 6)	1.0	ΔP(6, 5)	0.6
	10	Z(5, 6)	0.8	Z(2, 3)	1.0	Z(3, 2)	0.6
	11	Z(6, 5)	0.9	—	—	P(4, 5)	0.5
	12	—	—	—	—	ΔP(5, 4)	0.5
	13	—	—	—	—	H(9, 7)	0.4
	14	—	—	—	—	Z(5, 4)	0.5
	15	—	—	—	—	ΔP(7, 2)	0.4
Total			55.8		56.5		63.6

TABLE XIII

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	V′	19.7	U′	47.1	U′	15.4
	2	P(5, 6)	13.5	P(7, 6)	5.2	I_1	10.1
	3	Z(6, 3)	5.6	P(5, 2)	4.2	ΔP(5, 4)	9.9
	4	$\Delta\hat{Z}(6, 3)$	4.0	$\Delta\bar{Z}(5, 4)$	3.1	$\Delta\bar{Z}(6, 5)$	4.0
	5	η_0	3.2	P(6, 5)	1.1	Λ_T	1.7
	6	P(4, 5)	2.6	Z(5, 4)	1.4	ΔH(5, 6)	1.1
	7	$\Delta\hat{Z}(6, 5)$	1.6	H(5, 6)	1.2	$\Delta\bar{Z}(5, 4)$	1.1
	8	P(8, 5)	1.3	Z(7, 6)	0.6	P(3, 2)	0.7
	9	Z(4, 5)	1.1	Z(7, 2)	0.6	ΔP(4, 3)	0.9
	10	P(3, 6)	1.0	η_0	0.5	Z(4, 5)	0.8
	11	$\Delta\hat{Z}(5, 6)$	0.8	ΔP(6, 3)	0.5	—	—
	12	—	—	$\Delta\hat{Z}(7, 6)$	0.6	—	—
Total			54.4		66.1		45.7
24	1	P(5, 6)	25.3	U′	42.0	U′	32.3
	2	P(8, 3)	12.9	P(7, 6)	7.1	I_1	9.8
	3	V	5.1	P(5, 2)	5.6	$\Delta\bar{Z}(6, 5)$	7.4
	4	P(7, 6)	4.7	$\Delta\bar{Z}(5, 4)$	3.6	$\Delta\bar{Z}(6, 3)$	2.6
	5	$\Delta\hat{Z}(5, 6)$	3.2	Z(5, 4)	2.4	ΔP(4, 3)	1.2
	6	P(3, 2)	1.4	H(5, 6)	2.0	P(3, 2)	1.3
	7	Z(8, 5)	1.2	P(6, 5)	1.7	Z(5, 6)	1.2
	8	ΔP(4, 3)	1.0	$\Delta\bar{Z}(7, 6)$	1.3	Z(5, 2)	1.1
	9	P(6, 3)	1.3	Z(7, 6)	1.4	H(5, 4)	0.6
	10	ΔP(4, 5)	1.4	—	—	$\Delta\hat{Z}(5, 4)$	0.7
	11	ΔZ(8, 5)	0.6	—	—	—	—
	12	Z(4, 5)	0.9	—	—	—	—
	13	H(7, 2)	1.4	—	—	—	—
Total			60.4		67.1		58.2
36	1	P(5, 6)	24.4	U′	32.9	U′	38.3
	2	Z(6, 3)	13.5	P(7, 6)	6.5	I_2	12.7
	3	P(8, 5)	5.9	P(5, 3)	6.9	$\Delta\bar{Z}(6, 5)$	5.7
	4	Z(4, 5)	4.7	$\Delta\bar{Z}(5, 4)$	4.5	ΔP(5, 2)	2.0
	5	$\Delta\hat{Z}(6, 3)$	3.0	H(5, 4)	2.0	P(4, 3)	1.9
	6	$\Delta\hat{Z}(5, 6)$	2.0	H(5, 6)	3.6	ΔP(4, 3)	1.2
	7	Z(9, 1)	1.6	$\Delta\bar{Z}(7, 6)$	2.0	Z(5, 6)	1.3
	8	H(5, 6)	1.3	Z(7, 6)	1.2	—	—
	9	Z(5, 2)	0.9	η_0	0.9	—	—
	10	θ	1.6	P(7, 2)	1.2	—	—
Total			58.9		61.7		63.1

(12 hr) and central pressure (24 and 36 hr) are correlated best.

For Exp. 2, V´ is selected first for 12-hr northward displacement while P(5,6) is first at 24 and 36 hr. For the eastward displacement predictand, U´ is selected first for all three forecast intervals. This predictor is also selected first for all three forecast intervals for the change-in-central pressure predictand. Bailey [1] also found the strength of the wind field over cyclones to be an important factor in cyclone deepening. Further, synoptic meteorologists tend to associate large horizontal temperature differences with cyclone deepening, and one implication of a strong zonal thermal wind is the presence of a large north-south thermal gradient.

On independent data (see Table XIV), there is little difference between the two types of experiments. Note, however, that both are superior to climatology.

16. Eurasian Winter Cyclones

For Exp.1 [Table XV (a)] the first predictor selected for northward displacement is Z(7,2) for 12 and 24 hr, while Z(8,3) is selected first for 36 hr. Both of these predictors have positive regression coefficients (see the Appendix) which indicates that large 500-mb heights in this region are conducive to large northward cyclone displacements. For eastward displacement, the predictor combination of Z(5,6) and Z(5,2) is selected first for 12 and 24 hr. The locations of these predictors and the signs of their regression coefficients indicate that they represent the zonal steering component. For change in central pressure, a function of the initial central pressure is selected first.

Steering components (U´, V´) are selected first in Exp. 2 for all six displacement predictands. The central pressure predictand has, as its first selected predictor, the cyclone intensity, the forecast of 24-hr 500-mb height change at the initial cyclone location, and the initial central pressure, for 12, 24, and 36 hr, respectively.

On independent date (Table XIV) there are only small improvements made by Exp.2. Again, both experiments are superior to climatology.

17. Pacific Winter Cyclones

The first predictor selected for Exp. 1 [Table XVI (a)] is H(6,5) for 12- and 24-hr northward displacement, while Z(4,5) is selected second. Taken together, these predictors represent a meridional steering component. For eastward displacement, the 500-mb height at grid point (5,2) is selected first for all three forecast intervals. This predictor is located two grid intervals south of the cyclone location and carries

TABLE XIV

ROOT-MEAN-SQUARE ERRORS IN TESTS ON WINTER CYCLONES, 1959—1960

(independent sample)

Area	Forecast interval, hr	Exp. 1			Exp. 2			Climatology		
		N	E	D	N	E	D	N	E	D
Atlantic (255 cases)	12	1.64	1.76	5.31	1.52	1.72	5.18	2.34	2.87	6.41
	24	2.67	3.42	8.24	2.69	3.16	7.64	4.07	5.25	11.02
	36	3.94	5.17	10.85	3.52	4.88	10.09	5.51	7.39	14.60
Eurasia (140 cases)	12	1.91	1.65	3.80	1.72	1.57	3.59	2.37	2.02	4.01
	24	3.18	2.69	6.00	3.12	2.61	5.39	4.15	3.57	6.17
	36	4.43	4.14	7.51	4.30	4.04	6.98	5.80	5.24	8.27
Pacific (245 cases)	12	1.78	2.00	5.60	1.80	1.87	5.53	2.34	3.34	7.65
	24	2.62	3.48	8.26	2.34	3.42	7.48	3.86	6.05	12.42
	36	3.68	5.20	10.12	3.40	5.17	9.19	5.24	8.39	16.29

TABLE XV
PREDICTORS SELECTED BY SCREENING REGRESSION FOR EURASIAN WINTER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	Z(7, 2)	24.2	Z(5, 6)	12.5	I_2	10.6
	2	Z(4, 5)	9.9	Z(5, 2)	15.1	ΔP(5, 4)	4.9
	3	Z(6, 5)	8.7	Z(6, 5)	6.0	Z(1, 4)	2.3
	4	H(2, 3)	1.9	Z(6, 3)	3.2	—	—
	5	Z(8, 3)	1.4	H(3, 6)	2.1	—	—
	6	—	—	Z(4, 5)	2.2	—	—
Total			46.1		41.1		17.8
24	1	Z(7, 2)	29.8	Z(5, 6)	14.9	I_2	15.0
	2	Z(4, 5)	9.3	Z(5, 2)	16.9	Z(5, 2)	5.1
	3	Z(8, 5)	7.3	Z(6, 5)	9.1	ΔP(5, 4)	2.9
	4	H(2, 3)	3.0	Z(6, 3)	2.7	I_1	2.0
	5	H(6, 5)	1.7	P(4, 3)	2.6	Z(2, 5)	1.8
	6	P(8, 5)	1.7	Z(2, 5)	2.4	H(5, 4)	1.8
	7	ΔP(5, 4)	1.3	Z(4, 5)	1.9	—	—
	8	θ	1.2	θ	1.3	—	—
	9	ΔP(5, 2)	1.1	—	—	—	—
Total			56.4		51.8		28.6
36	1	Z(8, 3)	33.1	Z(7, 6)	13.4	P(5, 4)	18.8
	2	Z(4, 5)	8.7	Z(5, 2)	18.9	P(5, 6)	5.6
	3	P(8, 5)	5.6	Z(5, 6)	6.8	P(5, 2)	3.8
	4	H(6, 5)	2.2	Z(1, 4)	3.0	P(7, 6)	1.7
	5	H(2, 3)	1.3	P(4, 3)	2.8	—	—
	6	θ	2.2	H(9, 4)	1.6	—	—
	7	Z(5, 6)	1.2	Z(6, 5)	2.0	—	—
	8	—	—	ΔH(4, 5)	1.3	—	—
Total			54.3		49.8		29.9

TABLE XV

(b) Exp. 2

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	V'	31.8	U'	16.2	I_2	10.6
	2	$\Delta Z(4, 3)$	5.7	$\Delta\hat{Z}(5, 4)$	13.6	$\Delta\hat{Z}(6, 5)$	9.4
	3	$\Delta\hat{Z}(6, 5)$	3.9	$Z(5, 6)$	6.4	$\Delta\hat{Z}(5, 4)$	3.3
	4	$\Delta\hat{Z}(5, 2)$	2.9	A_T	3.2	$\Delta\eta_5$	3.8
	5	$P(4, 5)$	1.6	$Z(5, 2)$	2.2	—	—
	6	$Z(6, 3)$	2.9	$Z(7, 6)$	2.5	—	—
	7	$H(2, 3)$	1.9	—	—	—	—
Total			50.7		44.1		27.1
24	1	V'	36.0	U'	17.9	$\Delta\hat{Z}(5, 4)$	15.8
	2	$\Delta\hat{Z}(6, 5)$	6.7	$\Delta\hat{Z}(5, 4)$	16.8	I_2	10.7
	3	$\Delta\hat{Z}(5, 2)$	5.4	$Z(5, 6)$	7.7	$\Delta\hat{Z}(6, 5)$	9.3
	4	$Z(8, 3)$	3.2	$P(4, 3)$	3.9	—	—
	5	$P(5, 6)$	2.3	$Z(5, 2)$	2.1	—	—
	6	—	—	$Z(7, 6)$	4.7	—	—
	7	—	—	$\Delta\hat{Z}(7, 6)$	2.1	—	—
	8	—	—	$Z(7, 2)$	1.1	—	—
	9	—	—	$Z(2, 5)$	1.4	—	—
Total			53.6		57.7		35.8
36	1	V'	33.6	U'	16.9	$P(5, 4)$	18.8
	2	$Z(8, 3)$	9.1	$\Delta\hat{Z}(5, 4)$	15.1	$\Delta\hat{Z}(5, 4)$	11.0
	3	$\Delta\hat{Z}(6, 5)$	4.3	$Z(7, 6)$	8.1	$P(5, 6)$	8.7
	4	$P(5, 6)$	3.8	$Z(5, 2)$	5.4	$\Delta\hat{Z}(6, 5)$	4.2
	5	$P(8, 5)$	1.9	$H(5, 6)$	3.6	$P(6, 5)$	2.4
	6	$\Delta\hat{Z}(5, 2)$	1.7	$\Delta\hat{Z}(7, 6)$	2.6	ζ_T	1.6
	7	$Z(4, 5)$	0.8	$\Delta H(4, 5)$	1.7	$H(5, 2)$	1.7
	8	θ	1.5	$P(4, 3)$	1.1	θ	2.1
	9	$Z(3, 2)$	1.1	$H(8, 5)$	1.1	—	—
	10	—	—	$Z(3, 6)$	1.4	—	—
Total			57.8		57.0		50.5

TABLE XVI
PREDICTORS SELECTED BY SCREENING REGRESSION FOR
PACIFIC WINTER CYCLONES

(a) Exp. 1

Forecast interval, hr	Order of selection	$\hat{N}$		$\hat{E}$		$\hat{D}$	
		Predictor	% red.	Predictor	% red.	Predictor	% red.
12	1	H(6, 5)	14.6	Z(5, 2)	34.2	I_2	15.5
	2	Z(4, 5)	16.5	Z(6, 5)	14.2	ΔP(5, 4)	19.2
	3	Z(6, 3)	12.4	P(7, 6)	3.3	Z(3, 2)	1.7
	4	P(8, 5)	4.4	Z(5, 6)	1.2	H(4, 5)	2.0
	5	Z(3, 2)	2.0	Z(4, 3)	1.5	H(6, 3)	1.6
	6	I_1	0.7	ΔP(6, 5)	1.0	ΔZ(4, 3)	1.2
	7	ΔP(2, 5)	0.7	Z(7, 2)	0.7	—	—
	8	—	—	Z(2, 5)	0.8	—	—
	9	—	—	P(8, 3)	0.7	—	—
	10	—	—	P(4, 5)	0.9	—	—
	11	—	—	Z(7, 6)	0.8	—	—
Total			51.3		59.3		41.2
24	1	H(6, 5)	19.7	Z(5, 2)	35.8	Z(5, 2)	24.9
	2	Z(4, 5)	17.8	P(7, 6)	13.1	I_2	12.3
	3	Z(6, 3)	12.3	H(5, 6)	3.9	ΔP(5, 4)	10.6
	4	P(8, 5)	4.6	Z(4, 3)	1.3	ΔZ(4, 3)	1.6
	5	Z(3, 2)	1.7	P(6, 5)	1.2	H(4, 5)	1.2
	6	Z(8, 3)	1.3	P(5, 4)	1.0	P(7, 2)	2.1
	7	ΔP(2, 5)	0.9	ΔP(6, 5)	1.0	Z(5, 4)	1.1
	8	—	—	Z(7, 2)	0.6	ΔP(6, 3)	0.7
	9	—	—	P(8, 5)	0.8	—	—
	10	—	—	Z(2, 5)	0.7	—	—
Total			58.3		59.4		54.5
36	1	Z(8, 5)	23.3	Z(5, 2)	32.5	P(5, 4)	31.4
	2	Z(4, 5)	12.4	P(7, 6)	11.2	H(5, 2)	10.0
	3	Z(6, 3)	14.1	P(4, 5)	4.6	Z(4, 5)	5.7
	4	H(6, 5)	3.4	H(5, 6)	1.7	P(7, 2)	4.3
	5	ΔP(8, 5)	1.8	P(3, 6)	1.4	ΔP(5, 4)	3.9
	6	Z(3, 2)	1.2	ΔP(6, 5)	1.4	P(6, 5)	2.6
	7	ΔP(2, 5)	0.9	I_2	0.9	P(6, 3)	1.1
	8	Z(5, 6)	0.7	P(8, 5)	0.7	P(3, 6)	0.7
	9	—	—	Z(7, 2)	1.0	—	—
	10	—	—	ΔP(2, 3)	0.6	—	—
Total			57.8		56.0		59.7

TABLE XVI

(b) Exp. 2

Forecast interval, hr	Order of selection	$\bar{N}$ Predictor	$\bar{N}$ % red.	$\bar{E}$ Predictor	$\bar{E}$ % red.	$\bar{D}$ Predictor	$\bar{D}$ % red.
12	1	V'	26.8	U'	34.6	V	17.4
	2	Z(8, 3)	5.8	P(7, 6)	7.8	I_2	12.8
	3	Z(3, 6)	4.0	Z(5, 2)	7.2	ΔP(5, 4)	9.3
	4	$\Delta\dot{Z}(6, 5)$	2.5	Z(6, 5)	2.9	$\Delta\bar{Z}(6, 5)$	5.1
	5	$\Delta\bar{Z}(6, 3)$	3.2	$\Delta\bar{Z}(5, 2)$	2.1	P(2, 3)	1.5
	6	Z(6, 3)	2.2	A_T	1.3	$\Delta\eta_0$	1.3
	7	Z(4, 5)	4.6	$\Delta\dot{Z}(7, 6)$	0.9	—	—
	8	—	—	Z(5, 6)	0.6	—	—
	9	—	—	Z(4, 5)	0.7	—	—
	10	—	—	Z(3, 6)	1.1	—	—
	11	—	—	ΔP(6, 3)	0.7	—	—
	12	—	—	η_0	0.5	—	—
	13	—	—	$\Delta\dot{Z}(5, 4)$	0.8	—	—
	14	—	—	$\Delta\bar{Z}(6, 5)$	0.8	—	—
Total			49.1		62.0		47.4
24	1	V'	29.2	Z(5, 2)	35.8	Z(5, 2)	24.9
	2	Z(8, 5)	9.1	P(7, 6)	13.1	$\Delta\bar{Z}(5, 4)$	13.8
	3	P(5, 6)	6.1	H(5, 6)	3.9	I_2	7.2
	4	P(8, 3)	3.7	$\Delta\dot{Z}(7, 6)$	3.0	ΔP(5, 4)	6.9
	5	H(2, 5)	3.1	$\Delta\dot{Z}(5, 2)$	1.8	$\Delta\bar{Z}(6, 5)$	4.0
	6	$\Delta\dot{Z}(5, 6)$	2.8	Z(4, 3)	1.1	V	2.5
	7	$\Delta\dot{Z}(6, 3)$	1.6	$\Delta\dot{Z}(5, 4)$	1.0	Z(3, 2)	2.1
	8	Z(6, 3)	2.5	I_2	0.9	H(5, 4)	1.0
	9	Z(4, 5)	2.0	Z(3, 6)	0.8	P(7, 2)	1.3
	10	$\Delta\dot{Z}(8, 5)$	1.3	$\Delta\dot{Z}(9, 7)$	0.7	—	—
	11	$\Delta\dot{Z}(6, 5)$	1.1	$\Delta\bar{Z}(9, 4)$	0.7	—	—
	12	Z(5, 2)	1.0	P(4, 5)	0.5	—	—
	13	ΔP(2, 5)	0.6	P(8, 3)	0.6	—	—
	14	—	—	Z(7, 2)	0.7	—	—
Total			64.1		61.6		63.7
36	1	V'	27.5	Z(5, 2)	32.5	P(5, 4)	31.4
	2	Z(8, 5)	12.3	P(7, 6)	11.2	V	11.3
	3	P(5, 6)	7.5	P(4, 5)	4.6	$\Delta\dot{Z}(5, 4)$	6.4
	4	H(2, 5)	3.1	$\Delta\hat{Z}(7, 6)$	2.9	P(6, 5)	4.4
	5	$\Delta\dot{Z}(8, 5)$	3.5	H(7, 6)	2.3	ΔP(5, 4)	4.3
	6	$\Delta\dot{Z}(5, 6)$	2.5	$\Delta\dot{Z}(6, 3)$	1.8	P(6, 3)	4.1
	7	U'	2.3	P(3, 6)	1.0	$\Delta\hat{Z}(6, 5)$	3.4
	8	$\Delta\dot{Z}(6, 3)$	2.1	H(5, 6)	0.8	ΔP(5, 2)	1.0
	9	$\Delta\bar{Z}(6, 5)$	1.0	η_0	0.8	Z(3, 2)	0.5
	10	ΔP(8, 5)	0.6	$\Delta\bar{Z}(5, 4)$	0.8	—	—
	11	P(6, 3)	0.4	H(5, 4)	0.9	—	—
	12	P(5, 2)	1.0	—	—	—	—
Total			63.8		59.6		66.8

a regression coefficient which relates large 500-mb heights in this region to large eastward displacements.

With Exp. 2 [Table XVI (b)], the steering components are selected first for four of the six displacement predictands. For 24- and 36-hr eastward displacement, Z(5,2) is selected first as was the case in Exp. 1. The 12-hr change-in-central pressure predictand finds the magnitude of the thermal wind (V) being selected first. This is indicative of the association of cyclone deepening with the strength of the wind field (see Section 15).

On independent data (Table XIV), there again appears to be little difference between Exp. 1 and Exp. 2. Both are superior to climatology.

SECTION VII

CONCLUSIONS

Equations for the prediction of 12-, 24-, and 36-hr cyclone displacements and changes in central pressure have been derived for six summer-cyclone and three winter-cyclone areas. Where applied to an independent data sample, the equations remained stable and yielded results superior to climatology.

Equations which were derived using a number of complex predictors and 500-mb perfect prognoses were, in general, slightly superior to the simple-type equations. In those situations where the difference appears to be appreciable, such as some of the change-in-central-pressure predictands, an evaluation needs to be conducted to assess the loss of accuracy when operational prognoses are substituted for perfect prognoses.

APPENDIX

PREDICTION EQUATIONS

APPENDIX

PREDICTION EQUATIONS

The prediction equations derived from the regression analysis have the form

$$\hat{Y} = A_0 + A_1X_1 + A_2X_2 + \cdots + A_nX_n, \tag{AI-1}$$

where $\hat{Y}$ is the predictand, the A's are constant coefficients derived from the developmental sample, and the X's are the predictors selected by the screening procedure.

Each set of prediction equations consists of nine equations: the three predictands of northward displacement ($\hat{N}$), eastward displacement ($\hat{E}$), and change in central pressure ($\hat{D}$), for the forecast intervals of 12, 24, and 36 hr.

The pair of numbers that is associated with a given predictor in the equations refers to the grid location in the (K, L)-grid system of Fig. 2. The predictor symbols and units used in the equations are found in Table III. Predictand symbols and units are in Table II. The convention used for eastward displacement is that negative values of E refer to eastward displacement and positive values to westward displacement. To convert the eastward displacement from degrees of latitude to degrees of longitude, it is only necessary to multiply the computed value of E by the secant of the average latitude applicable to the forecast interval being considered. It should be recalled that for summer cyclones the (K, L)-reference point is (5,3), and for winter cyclones it is (5,4).

1. North American Summer Cyclones

1.1 Exp. 1

$$\hat{N}_{12} = 71.393 + 0.0049Z(7,2) - 0.0142Z(4,3) - 0.1190\Delta P(5,4) + 0.0064Z(8,5) - 0.0792P(1,1) + 0.0573Z(6,3) - 0.0279Z(5,4) - 0.0218Z(5,2)$$

$$\hat{E}_{12} = -2.3020 + 0.0037Z(6,5) - 0.0297Z(5,2) + 0.0296Z(5,4) + 0.1408\Delta P(6,3) - 0.1265\Delta P(4,3) + 0.0877I_2 - 0.0053Z(4,3) + 0.0998P(6,3) - 0.0959P(5,2)$$

$$\hat{D}_{12} = -27.190 + 0.9029I_1 + 0.0591\Delta Z(4,3) + 0.0676\Delta Z(5,2) + 0.0131H(4,5)$$

$$\hat{N}_{24} = 115.08 + 0.0123Z(7,2) - 0.0179Z(4,3) + 0.0191Z(8,5) - 0.0191\Delta Z(5,4) - 0.0007Z(4,5) - 0.1302P(1,1) + 0.1006Z(6,3) - 0.0594Z(5,4) - 0.0449Z(5,2) - 0.1476\Delta P(5,4)$$

$$\hat{E}_{24} = 0.3684 + 0.02225Z(6,5) - 0.0777Z(5,2) + 0.0541Z(5,4) - 0.0546\Delta Z(4,3) + 0.0515\Delta Z(6,3)$$

$$\hat{D}_{24} = 267.20 + 1.3200I_1 + 0.1703\Delta Z(4,3) - 0.1025\Delta Z(3,2) - 0.2691P(4,3) + 0.3123\Delta P(6,3)$$

$$\hat{N}_{36} = 143.40 + 0.0622Z(8,3) - 0.0232Z(4,3) - 0.1026\Delta Z(5,4) + 0.0326Z(8,5) - 0.0051Z(4,5) + 0.0192Z(7,2) - 0.1500P(2,3) - 0.0613H(8,3) + 0.0666H(6,3) - 0.0667Z(5,4) + 0.0665\Delta H(5,4) + 0.2210I_2 + 0.0208Z(1,4) - 0.0402Z(9,1)$$

$$\hat{E}_{36} = -1.9892 + 0.0476Z(6,5) - 0.0987Z(5,2) + 0.0506Z(5,4) - 0.0803\Delta Z(4,3) + 0.0642\Delta Z(6,3)$$

$$\hat{D}_{36} = 335.97 + 1.8115I_1 - 0.3857P(4,3) + 0.1190\Delta Z(4,3) + 0.3603\Delta P(6,3) + 0.0262H(4,5)$$

1.2 Exp. 2

$$\hat{N}_{12} = 21.535 + 0.0731V' - 0.0301\lambda - 0.1004\Delta P(5,4) - 0.0609P(3,2) + 0.0476P(8,3) - 0.0910P(5,4) + 0.0853P(5,2) + 0.0206\Delta\hat{Z}(5,2) - 0.0157\Delta\hat{Z}(5,4) + 0.0178U'$$

$$\hat{E}_{12} = -27.087 - 0.0004U' + 0.0082Z(6,5) + 0.0179\Delta\hat{Z}(6,5) + 4362.2A_T + 0.1184\Delta P(6,3) - 0.0359Z(5,2) + 0.0245Z(5,4) - 0.0165\Delta\hat{Z}(5,4) - 0.0734\Delta P(4,3) + 0.0315P(1,4)$$

$$\hat{D}_{12} = -2.6768 + 0.0881\Delta\hat{Z}(6,3) + 1.0850I_1 + 0.0534\Delta Z(4,3) - 103{,}860\Delta\eta_0$$

$$\hat{N}_{24} = 29.396 + 0.0971V' - 0.0472\lambda - 0.0959\Delta P(5,4) - 0.0919P(3,2) + 0.1488P(8,3) - 0.1051P(5,4) + 0.0581U' - 0.0347\Delta\hat{Z}(5,4) + 0.0400\Delta\hat{Z}(5,2) + 0.0240Z(7,6) - 0.0118Z(5,6) + 0.0211\Delta\hat{Z}(7,6) - 0.0234\Delta\hat{Z}(6,3)$$

$$\hat{E}_{24} = -19.381 - 0.0535U' + 0.0399Z(6,5) + 0.0509\Delta\hat{Z}(6,5) - 0.0308Z(5,2) - 0.0434\Delta\hat{Z}(5,4)$$

$$\hat{D}_{24} = -51.388 + 0.1481\Delta\hat{Z}(6,3) + 1.2759I_2 + 0.0887\Delta\hat{Z}(5,4) - 0.0010V^2 - 143{,}410\Delta\eta_0 + 0.1464P(3,6) - 0.0998P(4,5) + 11{,}912A_T + 0.0432\Delta H(2,3)$$

$$\hat{N}_{36} = -82.753 + 0.1096V' - 0.0752\lambda + 0.0990P(8,5) - 0.0576\Delta Z(5,4) - 0.1947P(5,4) + 0.0971U' - 0.0570\Delta\hat{Z}(5,4) + 0.0534\Delta\hat{Z}(5,2) + 0.1516P(8,3) + 0.0174H(8,5)$$

$$\hat{E}_{36} = -62.210 - 0.0378U' + 0.0692Z(6,5) + 0.0783\Delta\hat{Z}(6,5) - 0.0745Z(5,2) - 0.0633\Delta\hat{Z}(5,4) - 0.0510\Delta\hat{Z}(5,2) + 0.2680P(6,3) - 0.1991P(7,2)$$

$$D_{36} = 202.63 + 0.2004\Delta\hat{Z}(,3) + 1.0988I_2 + 0.0850\Delta\hat{Z}(5,4) - 0.0851U' - 0.2044P(5,3)$$

2. Atlantic Summer Cyclones

2.1 Exp. 1

$$\hat{N}_{12} = -21.705 + 0.0447P(7,2) - 0.1193P(5,4) + 0.0343Z(6,3) - 0.0199Z(4,3)$$
$$- 0.0095H(3,6) + 0.0094\Delta Z(5,2) - 0.0125\Delta H(6,3) + 0.0151P(2,5) - 0.0497\Theta$$
$$+ 0.0709P(5,2) - 0.0136Z(3,2) + 0.0096Z(8,3) + 0.0058Z(7,6)$$

$$\hat{E}_{12} = -5.7530 - 0.0362Z(5,2) + 0.0346Z(5,4) - 0.0228Z(4,3) + 0.0124Z(2,3)$$
$$- 0.0628\Delta P(4,3) + 0.0259Z(6,3) + 0.0211\Delta H(5,2) - 0.0129Z(7,2) + 0.0846I_2$$
$$+ 0.0444\Theta$$

$$\hat{D}_{12} = 84.876 + 0.0539\Delta Z(4,3) + 0.5751I_1 - 0.1716P(3,2) + 0.0842P(6,5) + 0.1485\Delta P(6,3)$$

$$\hat{N}_{24} = -47.007 + 0.0662P(7,2) - 0.2432P(5,4) + 0.0514Z(6,3) - 0.0088H(4,3)$$
$$+ 0.0529P(8,5) - 0.0213H(4,5) - 0.1295\Theta - 0.0407Z(3,2) + 0.0212H(9,1)$$
$$+ 0.0949P(5,2) + 0.0791P(8,3) + 0.0253H(6,5) - 0.0256H(5,4)$$

$$\hat{E}_{24} = 49.231 - 0.1346P(5,2) + 0.0864P(6,5) - 0.1046\Delta P(4,3) - 0.0361H(4,3)$$
$$+ 0.0292H(6,5) - 0.0246\Delta Z(7,2) + 0.0164Z(5,4) - 0.0424Z(5,2) + 0.0411Z(6,3)$$
$$- 0.0245Z(7,2) + 0.0148H(2,3)$$

$$\hat{D}_{24} = 291.27 - 0.4305P(5,3) + 0.3249\Delta P(5,2) + 0.0343H(4,5) + 0.3431\Delta P(6,3)$$
$$- 0.1581P(2,3) + 0.2343P(5,4)$$

$$\hat{N}_{36} = -432.51 + 0.1478P(8,3) - 0.0231Z(4,5) + 0.0817Z(6,3) - 0.1503Z(5,4) + 0.0616P(8,5)$$
$$+ 0.0959H(5,4) + 0.1266P(4,5) - 0.0488Z(3,2) - 0.1781\Theta + 0.0339H(6,5)$$
$$+ 0.1259P(5,2)$$

$$\hat{E}_{36} = 47.730 - 0.2729P(5,2) + 0.1044P(6,5) + 0.0566P(8,5) + 0.0459P(1,1) - 0.0585H(4,3)$$
$$+ 0.0416Z(6,5) - 0.0526\Delta Z(7,2) - 0.1627\Delta P(4,3) + 0.0324H(2,3) + 0.0923\Theta$$
$$- 0.0727Z(9,1) + 0.0624H(9,1)$$

$$\hat{D}_{36} = 512.03 - 0.5201P(5,3) + 0.3579\Delta P(5,2) + 0.0413H(4,5) - 0.2418P(2,3)$$
$$+ 0.1749P(6,5) + 0.2990\Delta P(6,3)$$

2.2 Exp. 2

$$\hat{N}_{12} = -70.210 + 0.0390V' + 0.0608P(7,2) + 0.0323P(8,5) - 0.1124P(5,4) + 0.0876P(6,3)$$
$$- 0.0141\Delta\hat{Z}(6,5) + 0.0089\Delta\hat{Z}(6,3) + 54{,}959\Delta\eta_0 + 0.0621\Delta P(5,2) + 0.0135\Delta\hat{Z}(8,5)$$
$$- 27{,}097\eta_0 - 0.0127Z(3,2) + 0.0154H(7,2)$$

$$\hat{E}_{12} = -36.543 + 0.0127U' + 0.0275V' + 0.0212P(6,5) - 0.0729\Delta P(4,3) - 0.0430P(5,2) + 0.0170\Delta\hat{Z}(6,5) + 0.0144H(6,5) - 0.0152\Delta\hat{Z}(5,2) - 0.0374Z(5,2) + 0.0258Z(5,4) + 0.0163\Delta Z(5,2) - 0.0107\Delta\hat{Z}(5,4) + 18{,}878\eta_5 + 0.0499P(6,3)$$

$$\hat{D}_{12} = -1.4158 + 0.0696\Delta\hat{Z}(6,3) - 0.0671V + 0.6859I_1 - 101{,}120\Delta\eta_0 + 0.1361\Delta P(4,3)$$

$$\hat{N}_{24} = -101.07 + 0.0919P(7,2) + 0.0602V' + 0.0692P(8,5) - 0.2501P(5,4) - 22{,}993\eta_5 + 0.0274\Delta\hat{Z}(8,5) + 0.1256\Delta P(5,2) + 0.1473P(6,3) + 0.0381P(2,5) + 0.0483U' - 0.0247\Delta\hat{Z}(6,5) + 0.0216Z(8,3) - 0.0182Z(3,2)$$

$$\hat{E}_{24} = -77.995 - 0.0092U' + 0.0544V' + 0.1204P(6,5) - 0.0621P(5,2) - 0.0353\Delta\hat{Z}(5,2) + 0.0468H(6,5) + 0.0420\Delta\hat{Z}(6,5) - 0.0442Z(5,2) - 0.0290\Delta\hat{Z}(5,4) + 0.1838P(6,3) + 5529.7\Delta A_T - 0.0912P(7,2) - 0.0807P(5,3)$$

$$\hat{D}_{24} = -107.25 - 0.1038V + 0.1233\Delta\hat{Z}(6,3) + 0.6912I_2 - 169{,}870\Delta\eta_0 + 124{,}660\eta_0 + 0.0478H(1,1) + 0.0525\Delta Z(6,3) + 0.0386\Delta\hat{Z}(6,5) + 0.1789\Delta P(5,2)$$

$$\hat{N}_{36} = -212.71 + 0.0813P(8,3) + 0.0301V' - 45{,}813\Delta\zeta_T - 0.0092Z(4,5) + 0.0324Z(7,2) + 0.1180P(8,5) + 0.0384\Delta\hat{Z}(8,5) + 0.0040\Delta\hat{Z}(7,2) - 0.0356\Delta\hat{Z}(6,5) - 0.0747Z(5,4) + 0.0565Z(6,3) + 0.0437\Delta\hat{Z}(6,3) - 0.0395\Delta\hat{Z}(5,4)$$

$$\hat{E}_{36} = -13.294 - 0.1084U' + 0.0699V' + 0.1622P(6,5) - 0.2624P(5,2) - 0.0510\Delta\hat{Z}(5,2) + 0.1065P(8,5)$$

$$\hat{D}_{36} = 379.10 - 0.5714P(5,3) + 0.1767\Delta\hat{Z}(6,3) - 0.2031U' + 0.2845P(5,4) - 0.1581P(2,3) + 0.0568\Delta\hat{Z}(6,5) + 0.2975\Delta P(4,3) + 0.0365Z(6,3)$$

3. European Summer Cyclones

3.1 Exp. 1

$$\hat{N}_{12} = -75.574 + 0.0256H(6,3) - 0.0462Z(5,4) - 0.0212H(3,2) + 0.0191Z(5,2) - 0.1131\Delta P(5,4) + 0.0473P(8,5) + 0.0891\Delta P(5,2) + 0.0231H(5,4) + 0.0147Z(7,2)$$

$$\hat{E}_{12} = -2.6362 + 0.0047P(6,5) - 0.0843\Delta P(4,3) + 0.0395\Delta P(5,2) - 0.0089P(5,2) + 0.0086Z(8,3) - 0.0321Z(5,2) + 0.0198Z(5,4) + 0.0277Z(6,3) + 0.2154I_1 - 0.0210Z(7,2)$$

$$\hat{D}_{12} = 101.93 + 0.5037I_2 + 0.0346\Delta Z(4,3) - 0.1210P(3,2) + 0.0311Z(5,4) + 0.2164\Delta P(5,4) - 0.0211Z(5,2)$$

$$\hat{N}_{24} = -116.47 + 0.0847H(6,3) - 0.0510Z(5,4) - 0.0397H(3,2) + 0.0868P(8,5) + 0.0224Z(5,2)$$

$$\hat{E}_{24} = 35.608 + 0.0252Z(6,5) - 0.0664Z(5,2) + 0.0739Z(6,3) - 0.1365\Delta P(4,3) - 0.0453P(1,7) + 0.2937I_1 - 0.0287Z(7,2)$$

$$\hat{D}_{24} = 426.44 - 0.4599P(5,3) + 0.4900\Delta P(5,4) + 0.0985P(6,5) + 0.0420\Delta Z(5,2) - 0.1639\Delta P(2,3) + 0.0555Z(5,4) - 0.0417Z(1,1) - 0.0868P(1,4)$$

$$\hat{N}_{36} = 31.531 + 0.0720H(6,3) - 0.0707Z(5,4) - 0.0580H(3,2) + 0.1400P(8,5) + 0.0217Z(5,2) + 0.0322H(7,2) - 0.1858\Delta P(5,4) + 0.1573\Delta P(3,6) + 0.1737\Delta P(7,2) - 0.0883P(9,7) - 0.1288\Theta - 0.0696P(5,6)$$

$$\hat{E}_{36} = -8.8601 + 0.0328Z(6,5) - 0.1084Z(5,2) + 0.1016Z(6,3) - 0.0480\Delta Z(4,3) - 0.0466\Delta Z(7,6) + 0.0224Z(2,3) - 0.0460Z(7,2) + 0.3805I_1 + 0.0465\Delta H(5,2)$$

$$\hat{D}_{36} = 573.94 - 0.6604P(5,3) + 0.1544P(6,5) + 0.5165\Delta P(5,4) - 0.2593\Delta P(2,3) - 0.3409\Delta P(3,6) + 0.0248Z(9,7) + 0.0396\Delta Z(5,2) - 0.1163P(1,4) + 0.0604Z(5,4) - 0.0564Z(1,1)$$

3.2 Exp. 2

$$\hat{N}_{12} = -25.013 + 0.0615V' - 0.0395\Delta P(5,4) + 0.0276Z(7,2) + 0.0286\Delta\hat{Z}(7,2) - 0.0162Z(5,4) - 0.0317\Delta\hat{Z}(5,4) + 0.0142\Delta Z(5,2) - 0.1090P(5,4) + 0.1117P(5,2) + 0.0171\Delta\hat{Z}(6,3)$$

$$\hat{E}_{12} = -13.972 - 0.0254U' - 0.0327\Delta\hat{Z}(5,2) - 0.0017V + 0.0109Z(6,5) - 0.0375Z(5,2) + 0.0331Z(6,3) + 0.1782I_1 - 0.0896\Delta P(3,2) + 0.0201\Delta\hat{Z}(7,2)$$

$$\hat{D}_{12} = -24.056 + 0.0689\Delta\hat{Z}(6,3) + 0.6523I_2 - 117{,}490\Delta\eta_0 + 0.0525\Delta\hat{Z}(5,4) + 0.0285Z(5,4) - 0.0165Z(2,3)$$

$$\hat{N}_{24} = 51.700 + 0.0901V' - 0.0635\Delta\hat{Z}(5,4) - 0.2160P(5,4) + 0.1382P(5,2) + 0.0277\Delta\hat{Z}(6,3) + 0.0750U' + 0.0290\Delta\hat{Z}(5,2) + 0.0383Z(7,2) - 0.0247H(3,2) + 0.0384\Delta\hat{Z}(7,2)$$

$$\hat{E}_{24} = -19.452 - 0.0622U' - 0.0618\Delta\hat{Z}(5,2) + 0.0412V + 0.0262Z(6,5) - 0.0675Z(5,2) + 0.0502Z(6,3)$$

$$\hat{D}_{24} = 96.628 + 0.1024\Delta\hat{Z}(5,4) - 0.1528U' + 1.0033I_2 + 0.133\Delta\hat{Z}(6,3) - 75{,}394\eta_5$$
$$- 0.0890P(2,3)$$

$$\hat{N}_{36} = 172.68 + 0.0324V' - 0.0959\Delta\hat{Z}(5,4) - 0.2022P(5,4) + 0.0854U' + 0.0419\Delta\hat{Z}(5,2)$$
$$+ 0.0244Z(8,3) - 0.0336H(3,2) + 0.0658Z(6,3) + 0.0504\Delta\hat{Z}(6,3) - 0.0401Z(5,4)$$

$$\hat{E}_{36} = - 30.505 - 0.0490U' - 0.0922\Delta\hat{Z}(5,2) + 0.0004V^2 + 0.0457Z(6,5) - 0.0903Z(5,2)$$
$$+ 0.0583Z(6,3) + 0.3566I_1 + 0.0409\Delta\hat{Z}(6,5)$$

$$\hat{D}_{36} = 371.53 - 0.3336P(5,3) + 0.1428\Delta\hat{Z}(6,3) + 0.1397\Delta\hat{Z}(5,4) + 0.0735P(6,5)$$
$$+ 0.8774I_2 - 0.1157U' - 89{,}830\eta_5 - 0.2229\Delta P(3,6) - 0.1285P(1,4) - 0.0569\Delta\hat{Z}(3,2)$$
$$+ 0.0200Z(9,7) - 0.0472Z(1,1) + 0.0445Z(5,4)$$

4. Eurasian Summer Cyclones

4.1 Exp. 1

$$\hat{N}_{12} = - 18.782 + 0.0932\Delta P(5,2) - 0.0260\Delta P(6,3) + 0.0127H(1,7) - 0.0201Z(4,3)$$
$$+ 0.0337Z(6,3) - 0.0158Z(5,4)$$

$$\hat{E}_{12} = - 8.9675 + 0.0051Z(6,5) - 0.0126Z(5,2) + 0.0337Z(5,4) - 0.0221Z(4,3)$$

$$\hat{D}_{12} = 158.74 + 0.9871I_1 - 0.1306P(4,3) + 0.0437\Delta Z(5,2) - 0.0376H(1,7)$$
$$+ 0.0201Z(8,5)$$

$$\hat{N}_{24} = - 45.751 + 0.0189Z(7,2) - 0.0593Z(4,3) + 0.0477Z(6,3) + 0.0173Z(2,3)$$
$$- 0.0300\Delta Z(5,4)$$

$$\hat{E}_{24} = - 153.67 + 0.0057Z(6,5) - 0.0364Z(5,2) + 0.0428Z(5,4) - 0.0256Z(4,3) + 0.1024P(2,3)$$
$$+ 0.0142H(3,2) + 0.0413P(9,7) - 0.1024\Delta P(4,3) + 0.0146Z(8,5) + 0.0582P(6,5)$$
$$- 0.2116P(5,3) + 0.2256P(6,3) - 0.0961P(7,2)$$

$$\hat{D}_{24} = 31.311 + 1.5085I_1 + 0.0182Z(8,5) - 0.0506Z(5,2) + 0.0717\Delta Z(5,2) - 0.0282Z(2,5)$$
$$+ 0.0425H(5,4) + 0.2446\Delta P(5,4)$$

$$\hat{N}_{36} = - 82.539 + 0.0180Z(7,2) - 0.0530Z(4,3) + 0.0695Z(6,3) + 0.0326H(2,5)$$
$$- 0.0392Z(5,4) - 0.0430\Delta Z(5,4) + 0.3070I_2 + 0.0166Z(8,5)$$

$$\hat{E}_{36} = - 154.54 + 0.0384Z(6,5) - 0.0671Z(5,2) + 0.0440H(5,4) + 0.1220P(2,3)$$

$$\hat{D}_{36} = 264.55 - 0.6956P(5,3) + 0.0552Z(8,5) + 0.4053P(5,2) - 0.0445H(1,7)$$
$$+ 0.0661\Delta Z(4,3)$$

4.2 Exp. 2

$$\hat{N}_{12} = -12.091 + 0.0412V' + 0.0107H(1,7) + 0.0809\Delta P(5,2) - 0.0221Z(5,4) + 0.0181Z(6,3)$$
$$- 0.0195\Delta\hat{Z}(5,4) + 0.0173\Delta\hat{Z}(5,2)$$

$$\hat{E}_{12} = -73.115 - 0.0512U' + 13,071A_T + 0.0110Z(6,5) + 0.0508P(2,3)$$

$$\hat{D}_{12} = +21.011 + 1.1079I_1 + 0.0712\Delta\hat{Z}(6,3) - 0.0682U' + 0.0558\Delta Z(1,1) - 0.0126Z(2,5)$$

$$\hat{N}_{24} = -25.961 + 0.1088V' + 0.0176H(1,7) - 0.0412\Delta\hat{Z}(5,4) + 0.0254\Delta\hat{Z}(5,2) - 0.0231Z(5,4)$$
$$+ 0.0198Z(8,3)$$

$$\hat{E}_{24} = -60.562 - 0.1073U' + 0.0247Z(6,5) - 0.0323\Delta\hat{Z}(5,2) + 19.785A_T + 0.1041P(2,3)$$
$$- 0.0928P(5,3)$$

$$\hat{D}_{24} = -1.9615 + 0.0937\Delta\hat{Z}(6,3) + 1.4151I_2 - 0.1301U' + 0.0661\Delta\hat{Z}(5,4) - 31,175\eta_5$$
$$- 0.0234Z(2,5) - 0.0342\Delta\hat{Z}(3,6) + 0.0244H(6,3) - 115,150\Delta\eta_5$$

$$\hat{N}_{36} = -15.726 + 0.1311V' - 0.0630\Delta\hat{Z}(5,4) - 0.0247P(5,4) + 0.0323Z(8,3) + 0.0483P(7,2)$$
$$+ 0.2955I_2 + 0.0372\Delta\hat{Z}(7,2) + 0.0261H(2,5) - 0.0254H(5,4) - 0.0342\Delta Z(5,4)$$
$$+ 0.0349\Delta\hat{Z}(5,2) + 0.1525P(6,3)$$

$$\hat{E}_{36} = -43.106 - 0.1157U' + 0.0700Z(6,5) - 0.0570\Delta\hat{Z}(5,2) - 0.0166Z(5,2) + 0.0250Z(8,5)$$
$$+ 17,008A_T + 0.0129P(2,3) - 0.1623P(5,3) - 0.0406H(6,5)$$

$$\hat{D}_{36} = 199.24 - 0.1887P(5,3) + 0.1025\Delta\hat{Z}(6,3) + 1.4724I_2 - 0.1592U' + 0.0785\Delta\hat{Z}(5,4)$$
$$- 85,093\eta_5 - 0.0279Z(2,5) + 0.0256Z(8,5)$$

5. Asian Summer Cyclones

5.1 Exp. 1

$$\hat{N}_{12} = -83.715 + 0.0667P(8,3) - 0.0948\Delta P(5,4) + 0.0193H(6,3) - 0.0155Z(4,5)$$
$$- 0.0146Z(3,2) + 0.0195Z(7,2)$$

$$\hat{E}_{12} = 0.0350 + 0.1248\Delta P(6,3) - 0.0913P(5,2) + 0.0764P(6,3) + 0.0122Z(6,5)$$
$$- 0.0169Z(5,2) + 0.0569\Theta - 0.0181\Delta Z(4,3) + 0.0275Z(5,4) - 0.0169Z(4,3)$$

$$\hat{D}_{12} = 204.50 + 0.2884\Delta P(5,2) - 0.2049P(5,3) + 0.1721\Delta P(6,3) + 0.0396\Delta Z(5,4)$$

$$\hat{N}_{24} = -240.32 + 0.1356P(8,3) - 0.1347\Delta P(5,4) + 0.0680H(6,3) - 0.0628Z(5,4)$$
$$+ 0.1236P(6,3) + 0.0157Z(6,5) - 0.0988\Theta - 0.0290Z(3,2) + 0.0123Z(8,5)$$
$$- 0.0123H(1,7)$$

$$\hat{E}_{24} = -62.593 + 0.1118\Theta + 0.0394Z(6,5) - 0.0507Z(5,2) + 0.1492\Delta P(6,3) - 0.0254\Delta Z(4,3)$$
$$+ 0.0589Z(6,3) - 0.0450Z(7,2) + 0.0389Z(1,1) + 0.0184Z(4,5) - 0.0308Z(4,3)$$

$$\hat{D}_{24} = 457.63 - 0.4831P(5,3) + 0.4172\Delta P(5,2) + 0.3484\Delta P(6,3) + 0.0482\Delta H(3,2)$$
$$+ 0.0213H(1,7) - 0.0662H(7,2) + 0.0594Z(5,4) + 0.2212\Delta P(4,3)$$

$$\hat{N}_{36} = -82.909 + 0.1542P(8,3) - 0.1659\Theta - 0.0796P(5,3) - 0.0228H(4,5) + 0.0373Z(7,2)$$
$$+ 0.0253Z(8,5) - 0.0390Z(3,2) - 0.0934\Delta P(3,6) + 0.0535Z(6,3) - 0.0471Z(5,4)$$

$$\hat{E}_{36} = -511.35 + 0.1798\Theta + 0.0579Z(6,5) - 0.1853Z(5,2) + 0.1849\Delta P(6,3) + 0.2060P(2,3)$$
$$+ 0.1283H(5,2) - 0.1282\Delta P(2,3) + 0.2494P(6,3) - 0.0258\Delta Z(4,3) + 0.0209Z(4,5)$$
$$- 0.0415Z(7,2) + 0.0435H(6,3)$$

$$\hat{D}_{36} = 664.43 - 0.6907P(5,3) + 0.5324\Delta P(5,2) + 0.4724\Delta P(6,3) + 0.0629\Delta H(3,2)$$
$$+ 0.0312H(1,7) - 0.0833H(7,2) + 0.0679Z(5,4)$$

5.2 Exp. 2

$$\hat{N}_{12} = -27.693 + 0.0671P(8,3) + 0.0275V' + 0.0339Z(7,2) - 0.0115Z(4,5) + 0.0243\Delta\hat{Z}(7,2)$$
$$- 0.0601\Delta P(5,4) - 0.0495P(5,4) - 0.0174Z(9,1) - 0.0111\Delta\hat{Z}(6,5)$$

$$\hat{E}_{12} = -9.6595 - 0.0564U' + 6194.1A_T + 0.0963\Delta P(6,3) - 0.0148\Delta Z(4,3) - 0.0191\Delta\hat{Z}(5,2)$$
$$+ 0.0206Z(6,5) - 0.0159Z(4,3) + 0.0178\Delta\hat{Z}(6,5)$$

$$\hat{D}_{12} = 124.24 + 0.0564\Delta\hat{Z}(6,3) - 0.3325P(5,3) + 0.2316\Delta P(5,2) + 0.0392\Delta\hat{Z}(5,4)$$
$$+ 0.0429\Delta Z(5,4) + 0.2069P(6,3) - 75{,}325\Delta\eta_0$$

$$\hat{N}_{24} = -95.471 + 0.0905P(8,3) - 0.0268\Delta\hat{Z}(6,5) + 0.0538V' - 0.0712\Theta - 0.1007P(5,4)$$
$$- 0.0384\Delta\hat{Z}(5,4) + 0.0385\Delta\hat{Z}(5,2) + 0.0515U' + 0.0232Z(8,5) - 0.0232Z(3,2)$$
$$+ 0.1082P(7,2) + 0.0206\Delta\hat{Z}(8,5)$$

$$\hat{E}_{24} = 96.505 - 0.1170U' + 0.1220\Delta P(6,3) - 0.3080P(5,2) + 0.0157P(6,5) - 0.0575\Delta\hat{Z}(5,2)$$
$$+ 0.1448P(6,3) + 0.0394\Delta\hat{Z}(6,3) + 0.0369V' + 0.0230Z(1,1) - 0.0381\Delta\hat{Z}(5,4)$$
$$- 0.0152\Delta H(5,4) + 0.0345\Delta\hat{Z}(6,5) + 0.0457Z(6,5) - 0.0435H(5,4)$$

$$\hat{D}_{24} = 378.37 + 0.0936\Delta\hat{Z}(6,3) - 0.6505P(5,3) + 0.4139\Delta P(5,2) + 0.0655\Delta\hat{Z}(6,5)$$
$$+ 0.3591P(6,3) - 102{,}830\Delta\eta_0 - 0.1037P(8,3) - 0.0262\Delta\hat{Z}(7,6) + 0.0487Z(5,4)$$
$$- 0.0396H(7,2) + 0.0427\Delta\hat{Z}(5,4)$$

$$\hat{N}_{36} = 85.463 + 0.1463P(8,3) - 0.0349\Delta\hat{Z}(6,5) + 0.0035V' - 0.1714\Theta - 0.2050P(5,4) - 0.0457\Delta\hat{Z}(5,4) + 0.0437\Delta\hat{Z}(5,2) - 0.0088U' + 0.0330Z(8,5) - 0.0815H(5,4) + 0.0702Z(6,3) + 0.0293\Delta\hat{Z}(8,5) - 0.0322Z(3,2)$$

$$\hat{E}_{36} = -232.51 - 0.0167U' - 0.0514\Delta\hat{Z}(5,2) + 0.0877Z(6,5) - 0.1168Z(5,2) + 0.0663\Delta\hat{Z}(6,5) + 0.0527\Delta\hat{Z}(7,2) - 0.0450\Delta\hat{Z}(5,4) + 0.1603\Theta + 0.1587P(2,3) + 0.0625H(5,2)$$

$$\hat{D}_{36} = 560.30 + 0.1165\Delta\hat{Z}(6,3) - 0.5620P(5,3) + 0.1225\Delta\hat{Z}(6,5) + 0.5034\Delta P(5,2) + 0.0637Z(6,5) - 0.0616H(7,2)$$

6. Pacific Summer Cyclones

6.1 Exp. 1

$$\hat{N}_{12} = 28.581 - 0.0739\Delta P(5,4) + 0.0353P(7,2) - 0.0697P(3,2) + 0.0379\Delta P(3,2) - 0.0093H(6,3) - 0.0203H(4,3) - 0.0446Z(5,4) + 0.0448Z(6,3) + 0.0092Z(8,3) + 0.0234H(5,4)$$

$$\hat{E}_{12} = -117.75 - 0.0588Z(5,2) + 0.0156Z(6,5) + 0.1782P(6,3) - 0.1446P(4,3) + 0.0304Z(5,4) + 0.0654P(2,3) - 0.0289H(4,3) + 0.0107H(2,3) + 0.0383H(5,2) + 0.0546\Theta - 0.0759\Delta P(3,2)$$

$$\hat{D}_{12} = -3.5733 + 0.3145\Delta P(5,2) + 0.7274I_1 + 0.2345\Delta P(5,4) - 0.0553\Delta H(6,3) + 0.0432\Delta Z(4,3)$$

$$\hat{N}_{24} = -109.22 + 0.0407Z(7,2) - 0.0825Z(5,4) + 0.0595Z(6,3) - 0.0441Z(3,2) + 0.0394P(7,6) + 0.0315H(3,2) + 0.0470P(3,6) - 0.0324\Delta H(7,2) + 0.0268\Delta H(5,4) - 0.0223H(2,5) + 0.0148Z(1,4) + 0.0132Z(6,5)$$

$$\hat{E}_{24} = -303.58 + 0.0508P(7,6) - 0.0948Z(5,2) + 0.0310Z(6,5) + 0.0069Z(6,3) - 0.0573Z(4,3) + 0.1089\Theta + 0.0251Z(2,3) + 0.0381Z(5,4) + 0.2143P(6,3) + 0.0661H(5,2)$$

$$\hat{D}_{24} = 70.223 + 0.4557\Delta P(5,2) + 0.8066I_2 - 0.0706H(5,2) + 0.3361\Delta P(5,4) + 0.0750H(5,4) + 0.3061\Delta P(4,3) + 0.0643\Delta H(5,2) - 0.0564\Delta Z(4,5) - 0.0432H(1,1) - 0.0717\Delta H(6,3) + 0.0644\Delta Z(7,2)$$

$$\hat{N}_{36} = -110.52 + 0.0580Z(7,2) - 0.0862Z(5,4) + 0.0579Z(6,3) - 0.1670P(3,2) + 0.0978P(8,5) + 0.1417P(2,5) - 0.0300Z(2,5) + 0.0189Z(1,4)$$

$$\hat{E}_{36} = -555.61 + 0.0855P(7,6) - 0.1308Z(5,2) + 0.0522Z(6,5) - 0.0485Z(4,3) + 0.0204Z(6,3) + 0.1895P(1,1) - 0.1954\Delta P(3,2) + 0.0306H(4,5) - 0.0547\Delta P(5,2) + 0.2570P(6,3) + 0.0847H(5,2)$$

$$\hat{D}_{36} = 277.54 - 0.0620Z(5,2) + 0.3633\Delta P(5,2) + 0.5156I_1 + 0.2063\Delta Z(4,3) + 0.1009Z(5,4) + 0.1254\Delta P(7,2) - 0.0718\Delta H(4,5) - 0.1049H(1,1) - 0.4172P(5,3) - 0.1407\Delta H(4,3) + 0.2612P(7,2) + 0.3305\Delta P(6,3)$$

6.2 Exp. 2

$$\hat{N}_{12} = -7.8087 + 0.0714V' - 0.0154\Delta\hat{Z}(6,5) + 0.0704P(7,2) - 0.0501P(3,2) - 0.0079Z(4,5) + 0.0071H(8,3) - 0.0834\Delta P(5,4) + 0.0140\Delta\hat{Z}(6,3) + 0.0228U' + 0.0154\Delta H(4,3) - 0.0725P(5,4) + 0.0611P(6,3)$$

$$\hat{E}_{12} = -55.630 - 0.0109U' + 10{,}175A_T + 0.0226V' + 0.0289Z(6,5) - 0.0211Z(5,2) + 0.0304\Delta\hat{Z}(6,5) + 0.0162\Delta\hat{Z}(7,2) - 0.0194\Delta\hat{Z}(5,4) + 0.0605\Theta + 0.0361P(2,3)$$

$$\hat{D}_{12} = -61.925 + 0.1775\Delta P(5,2) + 0.0492\Delta\hat{Z}(6,3) + 0.7857I_1 + 0.0401\Delta\hat{Z}(5,4) - 0.0915V + 0.1796\Delta P(4,3) + 0.0920P(5,4) + 0.0343\Delta Z(5,2) - 0.0175H(9,4)$$

$$\hat{N}_{24} = -4.7180 - 0.0304U' + 0.0183\Delta\hat{Z}(5,2) - 0.0339\Delta\hat{Z}(5,4) + 0.0589P(7,2) + 0.0307V' - 0.0239P(5,4) + 0.0222\Delta\hat{Z}(6,3) + 0.0809Z(6,3) - 0.0871Z(5,4) - 0.0206\Delta\hat{Z}(6,5) - 0.0955\Theta - 0.0533P(3,2) + 0.0385P(2,5) + 0.0232\Delta Z(5,2) - 0.0209\Delta Z(6,3)$$

$$\hat{E}_{24} = -29.572 - 0.0122U' + 0.0454V' + 0.0544Z(6,5) - 0.0042Z(4,3) + 0.0600\Delta\hat{Z}(6,5) - 0.0476\Delta\hat{Z}(5,4) + 0.0395\Delta\hat{Z}(6,3) + 52{,}212\eta_0 - 0.0356\Delta\hat{Z}(5,2) - 0.0392Z(5,2) + 8832.7A_T$$

$$\hat{D}_{24} = 26.159 + 0.3336\Delta P(5,2) - 0.1271V + 0.8161I_2 + 0.0921\Delta\hat{Z}(6,3) + 0.0826\Delta\hat{Z}(5,4) - 0.0542H(3,2) + 0.0393Z(5,4) + 0.2457\Delta P(4,3)$$

$$\hat{N}_{36} = -50.772 + 0.0184V + 0.0576P(8,3) - 0.1144P(3,2) - 0.0298\Delta\hat{Z}(6,5) - 0.0052V' + 0.0397\Delta\hat{Z}(5,2) + 0.0758P(2,5) + 0.0253Z(7,2) - 0.0063Z(4,5) + 0.0249Z(8,5) + 0.0315\Delta\hat{Z}(8,5) - 0.0263H(5,4) - 0.0391\Delta\hat{Z}(5,4) + 0.0679Z(6,3) - 0.0700Z(5,4)$$

$$\hat{E}_{36} = -74.207 - 0.0378U' + 0.0923P(7,6) + 0.0352V' - 0.0426\Delta\hat{Z}(4,3) + 67{,}982\eta_5 + 0.0590Z(6,5) + 0.0805\Delta\hat{Z}(6,5) - 0.0638Z(4,3) + 0.0259Z(2,3) + 0.0456\Delta\hat{Z}(6,3) - 0.0518\Delta\hat{Z}(5,4) - 0.0291\Delta\hat{Z}(5,2) - 0.0714P(1,7)$$

$$\hat{D}_{36} = 30.640 + 0.0053Z(5,2) + 0.1209\Delta\hat{Z}(6,3) + 1.1734I_2 - 0.1470V + 0.3088\Delta P(5,2) + 0.0470\Delta\hat{Z}(4,3) - 0.0846H(3,2) + 0.0914\Delta\hat{Z}(5,4) + 0.0627H(5,4) - 0.0784\Delta Z(4,5) + 0.0615\Delta Z(4,3)$$

7. Atlantic Winter Cyclones

7.1 Exp. 1

$$\hat{N}_{12} = 112.19 - 0.0557P(5,6) + 0.0129P(8,3) + 0.0196Z(6,5) - 0.0229Z(4,5) + 0.0470Z(6,3) - 0.0657\Delta P(4,5) - 0.0595P(5,4) - 0.0475P(3,2) + 0.0592\Delta P(5,2) - 0.0370H(6,3) + 0.0142H(7,2)$$

$$\hat{E}_{12} = 18.229 - 0.0213Z(5,2) + 0.0368Z(6,5) - 0.0111Z(5,4) + 0.0129Z(5,6) - 0.0218Z(4,3) - 0.0148Z(7,2) + 0.0100\Delta H(5,4) - 0.0278\lambda + 0.0072Z(2,3) - 0.0145H(6,5) + 0.0170H(5,2)$$

$$\hat{D}_{12} = 110.89 + 1.2367I_1 + 0.3887\Delta P(5,4) + 0.0166P(6,3) + 0.0578P(5,6) - 0.0644P(2,5) - 0.1470P(5,4) + 0.0440Z(4,5) - 0.0321Z(2,3) - 0.0516\Delta Z(1,4)$$

$$\hat{N}_{24} = 51.003 - 0.1324P(5,6) + 0.0702P(8,3) + 0.0330Z(6,3) - 0.0390Z(4,5) + 0.0208Z(6,5) - 0.1304\Delta P(4,5) + 0.0158Z(8,5) - 0.0894P(3,2) + 0.0469P(3,6)$$

$$\hat{E}_{24} = 122.07 - 0.0368Z(5,2) + 0.0205Z(7,6) + 0.0332Z(5,6) - 0.0252Z(4,5) - 0.0265\Delta Z(4,3) + 0.0598I_2 - 0.0182H(8,5) - 0.0942P(7,2) + 0.0302Z(6,5) - 0.0203Z(5,4) + 0.0223\Delta Z(9,7)$$

$$\hat{D}_{24} = 574.60 - 0.2342P(5,4) + 0.0473Z(5,6) - 0.1012H(5,2) + 0.3636\Delta P(5,4) + 0.8658I_2 - 0.1549P(2,5) - 0.2231P(3,2) + 0.2959\Delta P(4,3) + 0.0470Z(4,5) + 0.3777\Delta P(7,2) + 0.0281H(9,7)$$

$$\hat{N}_{36} = -10.377 - 0.1477P(5,6) + 0.0436Z(6,3) + 0.0977P(8,5) - 0.0314Z(4,5) + 0.0211Z(9,1) - 0.0240Z(3,2) - 0.1452\Delta P(4,5) + 0.0595P(3,6) - 0.1865\Theta - 0.0311Z(5,6) + 0.0266Z(6,5)$$

$$\hat{E}_{36} = 53.480 - 0.0580Z(5,2) + 0.0712Z(7,6) - 0.0137Z(8,5) - 0.1210P(6,3) - 0.0340\Delta Z(4,3) - 0.0390H(7,6) + 0.0447H(5,6) - 0.0490Z(4,5) + 0.1105P(5,6) + 0.0179Z(2,3)$$

$$\hat{D}_{36} = 719.32 - 0.8225P(5,4) + 0.0798Z(5,6) - 0.1062H(5,2) + 0.4922\Delta P(4,3) + 0.0143Z(4,5) - 0.2149P(2,5) - 0.3932\Delta P(3,2) + 0.0186Z(7,6) + 0.2181\Delta P(6,5) - 0.0387Z(3,2) + 0.2304P(4,5) + 0.2261\Delta P(5,4) + 0.0344H(9,7) + 0.0475Z(5,4) + 0.3810\Delta P(7,2)$$

7.2 Exp. 2

$$\hat{N}_{12} = 5.0463 + 0.0271V' - 0.0454P(5,6) + 0.0266Z(6,3) + 0.0169\Delta\hat{Z}(6,3) + 21{,}378\eta_0 - 0.0615P(4,5) - 0.0066\Delta\hat{Z}(6,5) + 0.0357P(8,5) - 0.0102Z(4,5) + 0.0338P(3,6) - 0.0105\Delta\hat{Z}(5,6)$$

$$\hat{E}_{12} = 8.2350 - 0.0394U' - 0.0038P(7,6) - 0.0859P(5,2) - 0.0183\Delta\hat{Z}(5,4) + 0.0781P(6,5) - 0.0130Z(5,4) + 0.0108H(5,6) + 0.0107Z(7,6) - 0.0083Z(7,2) + 22{,}712\eta_0 + 0.0515\Delta P(6,3) + 0.0086\Delta\hat{Z}(7,6)$$

$$\hat{D}_{12} = 101.99 - 0.0684U' + 1.2312I_1 + 0.3038\Delta P(5,4) + 0.0476\Delta\hat{Z}(6,5) + 10{,}516A_T + 0.0560\Delta H(5,6) + 0.0216\Delta\hat{Z}(5,4) - 0.1337P(3,2) + 0.1964\Delta P(4,3) + 0.0156Z(4,5)$$

$$\hat{N}_{24} = -33.289 - 0.1342P(5,6) + 0.0471P(8,3) + 0.0280V + 0.0505P(7,6) - 0.0214\Delta\hat{Z}(5,6) - 0.1134P(3,2) + 0.0208Z(8,5) + 0.0788\Delta P(4,3) + 0.1337P(6,3) - 0.1157\Delta P(4,5) + 0.0165\Delta\hat{Z}(8,5) - 0.0240Z(4,5) + 0.0308H(7,2)$$

$$\hat{E}_{24} = -52.057 - 0.0512U' + 0.0504P(7,6) - 0.1070P(5,2) - 0.0413\Delta\hat{Z}(5,4) - 0.0462Z(5,4) + 0.0254H(5,6) + 0.1050P(6,5) + 0.0236\Delta\hat{Z}(7,6) + 0.0211Z(7,6)$$

$$\hat{D}_{24} = 187.14 - 0.1373U' + 1.3254I_1 + 0.0969\Delta\hat{Z}(6,5) + 0.0292\Delta\hat{Z}(6,3) + 0.3422\Delta P(4,3) - 0.2011P(3,2) + 0.0355Z(5,6) - 0.0711Z(5,2) + 0.0443H(5,4) + 0.0386\Delta\hat{Z}(5,4)$$

$$\hat{N}_{36} = 139.91 - 0.1993P(5,6) + 0.0748Z(6,3) + 0.1001P(8,5) - 0.0297Z(4,5) + 0.0388\Delta\hat{Z}(6,3) - 0.0417\Delta\hat{Z}(5,6) + 0.0112Z(9,1) - 0.0319H(5,6) - 0.0409Z(5,2) - 0.2258\Theta$$

$$\hat{E}_{36} = 157.77 - 0.0180U' + 0.1083P(7,6) - 0.1662P(5,3) - 0.0611\Delta\hat{Z}(5,4) - 0.0663H(5,4) + 0.0440H(5,6) + 0.0406\Delta\hat{Z}(7,6) + 0.0320Z(7,6) + 80{,}839\eta_0 - 0.1298P(7,2)$$

$$\hat{D}_{36} = 264.74 - 0.2382U' + 1.2951I_2 + 0.1388\Delta\hat{Z}(6,5) + 0.5365\Delta P(5,2) - 0.3391P(4,3) + 0.4104\Delta P(4,3) + 0.0377Z(5,6)$$

8. Eurasian Winter Cyclones

8.1 Exp. 1

$$\hat{N}_{12} = -7.9447 + 0.0093Z(7,2) - 0.0258Z(4,5) + 0.0205Z(6,5) - 0.0121H(2,3) + 0.0122Z(8,3)$$

$$\hat{E}_{12} = -13.093 + 0.0141Z(5,6) - 0.0142Z(5,2) + 0.0254Z(6,5) - 0.0194Z(6,3) + 0.0151H(3,6) - 0.0130Z(4,5)$$

$$\hat{D}_{12} = 22.382 + 0.7782I_2 + 0.1874\Delta P(5,4) - 0.0151Z(1,4)$$

$$\hat{N}_{24} = -58.578 + 0.0257Z(7,2) - 0.0383Z(4,5) + 0.0121Z(8,5) - 0.0264H(2,3) + 0.0221H(6,5) + 0.0715P(8,5) - 0.0954\Delta P(5,4) - 0.1066\Theta + 0.1037\Delta P(5,2)$$

$$\hat{E}_{24} = 16.382 + 0.0324Z(5,6) - 0.0259Z(5,2) + 0.0520Z(6,5) - 0.0291Z(6,3) - 0.0709P(4,3) + 0.0213Z(2,5) - 0.0223Z(4,5) + 0.0922\Theta$$

$$\hat{D}_{24} = 51.690 + 2.0903I_2 - 0.0411Z(5,2) + 0.2774\Delta P(5,4) - 1.3734I_1 - 0.0185Z(2,5) + 0.0281H(5,4)$$

$$\hat{N}_{36} = -96.145 + 0.0396Z(8,3) - 0.0372Z(4,5) + 0.1354P(8,5) + 0.0332H(6,5) - 0.0303H(2,3) - 0.1959\Theta - 0.0227Z(5,6)$$

$$\hat{E}_{36} = 81.076 + 0.0266Z(7,6) - 0.0725Z(5,2) + 0.0303Z(5,6) + 0.0264Z(1,4) - 0.1253P(4,3) - 0.0189H(9,4) + 0.0333Z(6,5) - 0.0372\Delta H(4,5)$$

$$\hat{D}_{36} = 21.962 - 0.5436P(5,4) + 0.1852P(5,6) + 0.2232P(5,2) + 0.1049P(7,6)$$

8.2 Exp. 2

$$\hat{N}_{12} = 37.095 + 0.0462V' + 0.0154\Delta Z(4,3) - 0.0191\Delta\hat{Z}(6,5) + 0.0234\Delta\hat{Z}(5,2) - 0.0472P(4,5) + 0.0168Z(6,3) - 0.0107H(2,3)$$

$$\hat{E}_{12} = -7.8003 - 0.0399U' - 0.0244\Delta\hat{Z}(5,4) + 0.0111Z(5,6) + 5{,}557.6A_T - 0.0154Z(5,2) + 0.0087Z(7,6)$$

$$\hat{D}_{12} = -3.613 + 0.7188I_2 + 0.0457\Delta\hat{Z}(6,5) + 0.0388\Delta\hat{Z}(5,4) - 126{,}700\Delta\eta_5$$

$$\hat{N}_{24} = 29.973 + 0.1000V' - 0.0481\Delta\hat{Z}(6,5) + 0.0369\Delta\hat{Z}(5,2) + 0.0168Z(8,3) - 0.0588P(5,6)$$

$$\hat{E}_{24} = 56.577 - 0.0770U' - 0.0446\Delta\hat{Z}(5,4) + 0.0223Z(5,6) - 0.0926P(4,3) - 0.0207Z(5,2) + 0.0269Z(7,6) + 0.0302\Delta\hat{Z}(7,6) - 0.0158Z(7,2) + 0.0090Z(2,5)$$

$$\hat{D}_{24} = -5.2840 + 0.0752\Delta\hat{Z}(5,4) + 1.0176I_2 + 0.0869\Delta\hat{Z}(6,5)$$

$$\hat{N}_{36} = 32.345 + 0.0553V' + 0.0288Z(8,3) - 0.0533\Delta\hat{Z}(6,5) - 0.0915P(5,6) + 0.1018P(8,5) + 0.0272\Delta\hat{Z}(5,2) - 0.0240Z(4,5) - 0.2183\Theta - 0.0223Z(3,2)$$

$$\hat{E}_{36} = 56.975 - 0.0835U' - 0.0632\Delta\hat{Z}(5,4) + 0.0495Z(7,6) - 0.0425Z(5,2) + 0.0318H(5,6) + 0.0461\Delta\hat{Z}(7,6) - 0.0410\Delta H(4,5) - 0.1144P(4,3) - 0.0199H(8,5) + 0.0148Z(3,6)$$

$$\hat{D}_{36} = 276.74 - 0.5226P(5,4) + 0.1274\Delta\hat{Z}(5,4) + 0.1583P(5,6) + 0.0647\Delta\hat{Z}(6,5) + 0.1998P(6,5) - 156{,}420\zeta_T - 0.0574H(5,2) - 0.2522\Theta$$

9. Pacific Winter Cyclones

9.1 Exp. 1

$$\hat{N}_{12} = -66.393 + 0.0242H(6,5) - 0.0303Z(4,5) + 0.0277Z(6,3) + 0.0455P(8,5) - 0.0101Z(3,2) + 0.0978I_1 + 0.0403\Delta P(2,5)$$

$$\hat{E}_{12} = -15.579 - 0.0155Z(5,2) + 0.0193Z(6,5) + 0.0444P(7,6) + 0.0137Z(5,6) - 0.0191Z(4,3) + 0.0506\Delta P(6,5) - 0.0198Z(7,2) + 0.0083Z(2,5) + 0.0492P(8,3) - 0.0406P(4,5) - 0.0080Z(7,6)$$

$$\hat{D}_{12} = 26.785 + 0.7905I_2 + 0.2784\Delta P(5,4) - 0.0240Z(3,2) + 0.0382H(4,5) - 0.0307H(6,3) + 0.0371\Delta Z(4,3)$$

$$\hat{N}_{24} = -125.69 + 0.0404H(6,5) - 0.0549Z(4,5) + 0.0406Z(6,3) + 0.0746P(8,5) - 0.0156Z(3,2) + 0.0176Z(8,3) + 0.0792\Delta P(2,5)$$

$$\hat{E}_{24} = -82.762 - 0.0241Z(5,2) + 0.0753P(7,6) + 0.0311H(5,6) - 0.0285Z(4,3) + 0.0936P(6,5) - 0.0824P(5,4) + 0.0966\Delta P(6,5) - 0.0219Z(7,2) + 0.0563P(8,5) + 0.0086Z(2,5)$$

$$\hat{D}_{24} = -226.56 - 0.0652Z(5,2) + 1.1879I_2 + 0.3596\Delta P(5,4) + 0.0540\Delta Z(4,3) + 0.0705H(4,5) + 0.2851P(7,2) - 0.0424Z(5,4) + 0.1967\Delta P(6,3)$$

$$\hat{N}_{36} = -72.455 + 0.0346Z(8,5) - 0.0522Z(4,5) + 0.0502Z(6,3) + 0.0491H(6,5) + 0.1380\Delta P(8,5) - 0.0206Z(3,2) + 0.1031\Delta P(2,5) - 0.0196Z(5,6)$$

$$\hat{E}_{36} = -98.605 - 0.0556Z(5,2) + 0.1557P(7,6) - 0.1792P(4,5) + 0.0365H(5,6) + 0.1065P(3,6) + 0.1612\Delta P(6,5) + 0.1999I_2 + 0.0934P(8,5) - 0.0269Z(7,2) + 0.1041\Delta P(2,3)$$

$$\hat{D}_{36} = 285.36 - 1.0006P(5,4) - 0.1057H(5,2) + 0.0731Z(4,5) + 0.2514P(7,2) + 0.5829\Delta P(5,4) + 0.2719P(6,5) + 0.3480P(6,3) - 0.1068P(3,6)$$

9.2 Exp. 2

$$\hat{N}_{12} = -15.822 + 0.0402V' + 0.0109Z(8,3) + 0.0006Z(3,6) - 0.0189\Delta\hat{Z}(6,5) + 0.0246\Delta\hat{Z}(6,3) + 0.0199Z(6,3) - 0.0235Z(4,5)$$

$$\hat{E}_{12} = -20.230 - 0.0288U' + 0.0188P(7,6) - 0.0229Z(5,2) + 0.0179Z(6,5) - 0.0085\Delta\hat{Z}(5,2) + 2{,}303.4A_T + 0.0086\Delta\hat{Z}(7,6) + 0.0131Z(5,6) - 0.0195Z(4,5) + 0.0099Z(3,6) + 0.0447\Delta P(6,3) + 30{,}060\eta_0 - 0.0132\Delta\hat{Z}(5,4) + 0.0124\Delta\hat{Z}(6,5)$$

$$\hat{D}_{12} = 84.614 - 0.0961V + 0.8255I_2 + 0.4651\Delta P(5,4) + 0.0532\Delta\hat{Z}(6,5) - 0.0876P(2,3) + 131{,}030\Delta\eta_0$$

$$\hat{N}_{24} = 7.8925 + 0.0293V' + 0.0256Z(8,5) - 0.0542P(5,6) + 0.0216P(8,3) - 0.0065H(2,5) - 0.0165\Delta\hat{Z}(5,6) + 0.0352\Delta\hat{Z}(6,3) + 0.0544Z(6,3) - 0.0320Z(4,5) + 0.0200\Delta\hat{Z}(8,5) - 0.0228\Delta\hat{Z}(6,5) - 0.0275Z(5,2) + 0.0692\Delta P(2,5)$$

$$\hat{E}_{24} = -113.20 - 0.0406Z(5,2) + 0.1271P(7,6) + 0.0289H(5,6) + 0.0272\Delta\hat{Z}(7,6) - 0.0183\Delta\hat{Z}(5,2) - 0.0175Z(4,3) - 0.0219\Delta\hat{Z}(5,4) + 0.1576I_2 + 0.0174Z(3,6) - 0.0153\Delta\hat{Z}(9,7) - 0.0174\Delta\hat{Z}(9,4) - 0.0609P(4,5) + 0.1043P(8,3) - 0.0215Z(7,2)$$

$$\hat{D}_{24} = -187.54 - 0.0358Z(5,2) + 0.0423\Delta\hat{Z}(5,4) + 1.2757I_2 + 0.3564\Delta P(5,4) + 0.1026\Delta\hat{Z}(6,5) - 0.1398V - 0.0379Z(3,2) + 0.0573H(5,4) + 0.2135P(7,2)$$

$$\hat{N}_{36} = 95.978 + 0.0921V' + 0.0417Z(8,5) - 0.1255P(5,6) - 0.0248H(2,5) + 0.0305\Delta\hat{Z}(8,5) - 0.0286\Delta\hat{Z}(5,6) + 0.0433U' + 0.0378\Delta\hat{Z}(6,3) - 0.0272\Delta\hat{Z}(6,5) + 0.0798\Delta P(8,5) + 0.1488P(6,3) - 0.1476P(5,2)$$

$$\hat{E}_{36} = -134.92 - 0.0511Z(5,2) + 0.2219P(7,6) - 0.1525P(4,5) + 0.0508\Delta\hat{Z}(7,6) + 0.0274H(7,6) - 0.0130\Delta\hat{Z}(6,3) + 0.0852P(3,6) + 0.0363H(5,6) + 78{,}594\eta_0 - 0.0322\Delta\hat{Z}(5,4) - 0.0312H(5,4)$$

$$\hat{D}_{36} = 100.12 - 0.8838P(5,4) - 0.1369V + 0.0525\Delta\hat{Z}(5,4) + 0.3036P(6,5) + 0.4089\Delta P(5,4) + 0.5197P(6,3) + 0.1051\Delta\hat{Z}(6,5) + 0.2938\Delta P(5,2) - 0.0260Z(3,2)$$

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13. ABSTRACT

This report presents results and equations for the 12-, 24-, and 36-hr prediction of cyclone displacement and change in central pressure for the Northern Hemisphere. For application of these equations to summer cyclones, the Northern Hemisphere was divided into six areas; for application to winter cyclones, only three of these areas were treated because the other three were covered previously.

The technique employed features a moving-coordinate grid system for predictor tabulation, and a screening regression analysis for the derivation of the prediction equations.

These equations were tested on an independent data sample and yielded results superior to climatology for all areas tested. The incorporation of 500-mb perfect prognoses as predictors appeared to have only limited success.

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